MINUTES

OF THE

SOCIETY

FOR

PHILOSOPHICAL EXPERIMENTS

AND

CONVERSATIONS.

LONDON:

Printed for T. CADELL, Junior, and W. DAVIES
(Succeſſors to Mr. CADELL), in the *Strand.*

1795.

ADVERTISEMENT

OF THE

EDITOR.

HAVING found it impoſſible to execute the whole of this volume within the time preſcribed, in conformity with the title, and the plan of the firſt ſheets, I think it incumbent on me to declare that many of the Honourable members who have ſupported this inſtitution with their ſubſcriptions, have been prevented by official and important engagements from paying any attention to the proceedings of this firſt ſeſſion; and that even the Committee of Publication have not had the intended opportunities of improving theſe pages, to make them worthy of their ſanction. The imperfections and errors are therefore imputable to the Editor alone; who requeſts the

the indulgence of the reader, in confideration of the daily duties of his profession, and the hurry with which the numerous subjects of this volume have been abstracted from the minutes, and printed as fast as the Press could be supplied with Copy. The first meeting of this year being announced for Saturday next, the 31st instant.

Greek-Street, Soho,
Jan. 24, 1795.

MINUTES

OF THE

SOCIETY

FOR

PHILOSOPHICAL EXPERIMENTS

AND

CONVERSATIONS,

Instituted in London,

25th Jan. 1794.

The SOCIETY for PHILOSOPHICAL EXPERIMENTS and CONVERSATIONS having reſolved to print the minutes of their meetings, under the inſpection of A COMMITTEE OF PUBLICATION, and having appointed their EXPERIMENTER as EDITOR, he conſiders it as a part of his duty to expreſs his obligations to the Honourable Members, and particularly to thoſe who in *November* 1793 encouraged him to offer the following propoſals.

PHILOSOPHICAL EXPERIMENTS

AND

CONVERSATIONS.

DOCTOR HIGGINS is encouraged to aſſiſt in the Inſtitution of a Weekly Meeting of Gentlemen, who have a taſte for Philoſophical Experiments and Converſations, and are deſirous that the various talents of many may thus be united and exerted, in the contrivance and performance of deciſive experiments, in the eſtabliſhment of true inductions, and in uſeful applications of the lateſt diſcoveries in the CHEMICAL department of NATURAL PHILOSOPHY.

The firſt meeting will be held on *Saturday* the 25th of *Jan.* 1794, at eight o'clock in the evening, at Dr. Higgins's Houſe, and the ſubſequent Weekly Meetings during the Seſſion of Parliament, will be held on the

Days and under the Regulations which ſhall be voted at the firſt Meeting.

Dr. Higgins's extenſive Apparatus will be ſubſervient to the purpoſes of theſe Meetings, and will be augmented in proportion to the number of Subſcribers; and all meritorious communications will be reſpectfully recorded.

The admiſſion of proper Members is for the preſent committed to Dr. Higgins, who is to receive FIVE GUINEAS of each Subſcriber for the year; but after the firſt Meeting, the admiſſion will be by Ballot.

Any Subſcriber who ſhall be unwilling to adopt the Regulations of the firſt Meeting, ſhall have his ſubſcription immediately returned.

GREEK STREET, SOHO,
November 20, 1794

In

In confequence of thefe propofals, and fubfequent letters of invitation, the number of fubfcribing members amounted to fifty before the firft meeting, which was held on the 25th of *January*, 1794, fince which time other gentlemen have been elected. The fociety now confifts of the following members.

STANHOPE, Earl, *Mansfield Street.*
Beverly, Earl, *Portman Square.*
Pelham, Hon. Mr. *Stretton Street.*
Ingelby, Sir John, *St. James's Street.*
Barrington, The Hon. Daines, *Temple.*
Conway, Field Marfhal, *Soho Square.*
Duval, Rev. Doctor, *Newman Street.*
Eden, Sir Fred. Baronet, *Lincoln's Inn Fields.*
Robinfon, John, *Newman Street.*
Collins, Thomas, *Berners Street.*
Brocklefby, Doctor, *Norfolk Street.*
Coxwell, Henry, *Temple Bar.*
Godfrey, Amb. *Southampton Street.*
Cook, Charles Gomond, *Southampton Street.*
Burnett, Robert, *Vauxhall.*
Lewis, William, *Holborn.*
Johnfon, Jofeph, *Pimlico.*

Payne, Samuel, *Vauxhall.*
Bifhop, Charles, *Ruffel Place.*
Symmons, John, *Paddington.*
Devaynes, John, *Spring Gardens.*
Bennet, R. H. A. *Beckenham.*
Pitcairn, Doctor, *Lincoln's Inn Fields.*
Impey, Sir Elijah, *Wimpole Street.*
Latham, Doctor, *Effex Street.*
Ellis, John, *Portland Place.*
Scott, Sir William, *Doctors Commons.*
Delamaine, John, *Margaret Street.*
Fuller, John, *New Bond Street.*
Vivian, John, *Bedford Square.*
Harrifon, George, *Southampton Row, Bloomfbury.*
Blunt, Thomas, *Cornhill.*
Collins, John, *Berners Street.*
Vaux, George, *Coleman Street.*
Campbell, ——, *Oxford Street.*
Brand, Thomas, *Soho Square.*
Wright, John, *Clapham.*
Grubb, John, *Lincoln's Inn Fields.*
Johnfon, William, *Vauxhall.*
Scott, Claud, *Gower Street.*
Allardyce, Alexander, *St. James's Street.*
Wilkison, Thomas, *Breton Street.*
Partington, Thomas, *Temple.*
Tuffen, John Furnell, *Thames Street.*

Blane, William, *Arlington Street.*
Woodmafon, James, *Gerrard Street.*
Fofter, Andrew, *Lambeth.*
Couft, Francis, *Norfolk Street.*
Hyett, Benj. *Charles Street, Berkley Square.*
Hogg, ——, *Queen Anne Street Eaft.*
Young, Tho. *Little Queen's Street, Weftminfter.*
Bullock, John, *George Street, York Buildings.*
Powell, Doctor Richard, *Barlett's Buildings.*
Wyndham, The Right Hon. Will. *Hill Street.*
Gordon, William, *St. John Street.*
Burnett, J. Faffett, *Chatham Place, Black Friars.*
Lawrence, Doctor Trench, *Doctors Commons.*
Franks, William, *Bedford Square.*
Finlay, John, *Corps of Engineers, Whitehall.*
Bullen, John, *Morgan's Lane, Southwark.*
Moyes, Dr. *St. Martin's Lane, Charing Crofs.*
Goodhew, Mr. *Deptford.*
Bagfhaw, Rev. Mr. *Cecil Street, Strand.*
Defbares, Governor, *Eaton Street.*
Voght, ——, *Ofborn's Hotel.*
Thomas, William, *Alfop's Buildings.*
Allen, William, *Plough Court, Lombard Street.*
Grant, Major, *Hill Street, Berkley Square.*
Hill, Daniel, *Great Ruffel Street.*

By six distinct and unanimous resolutions of the 25th of *January*, the following appointments were made, and subjoined to the list of members by order of the Society.

CHAIRMAN.

FIELD MARSHAL CONWAY.

DEPUTY CHAIRMEN.

Sir JOHN INGELBY,
Sir FRED. EDEN,
Doctor LATHAM.

SECRETARIES.

JOHN GRUBB.
JOHN TAYLOR.

DIDACTIC EXPERIMENTER.

Doctor BRY. HIGGINS.

ASSISTANT EXPERIMENTERS.

Mr. JOSEPH JOHNSON.
Mr. THOMAS YOUNG.
Rev. Mr. CREVEL.

MACHINIST.

Mr. T. BLUNT.

On

On the ſame evening, when the united and repeated wiſhes of the ſociety had prevailed on Marſhal CONWAY to take the chair, it was reſolved unanimouſly,

7. That all future members be propoſed and ſeconded, and ballotted for at the enſuing meeting.

8. That three negative balls ſhall exclude.

9. That a weekly meeting be held on each Saturday, during the Seſſion of Parliament, at eight o'clock in the evening.

10. That the converſations of the ſociety be confined to Phyſicks, and the improvement of Arts.

11. That the order of LAVOISIER and Doctor CRAWFORD, ſo far as they can be combined, be purſued during the firſt hour of each meeting.

12. That every propoſition of a member relative to Phyſicks, ſhall be reſpectfully attended to; but that the priority of inveſtigation ſhall be determined by a majority of the members preſent.

13. That each member have the right of introducing a viſitor at any meeting of this year.

14. That

14. That at each meeting, the ſubjects to be inveſtigated by the Experimenter, during the firſt hour of the next meeting, ſhall be announced by the ſecretary, and ſhall, during this interval, appear in writing on a conſpicuous tablet in the laboratory, for the information of the members.

A conſiderable time having been expended in drawing up theſe reſolutions, the propoſition for the next meeting was announced by the Experimenter, and the members were informed that the beſt books on ſubjects under examination, ſhould always be ready for their peruſal in the drawing-room. They were invited to view the experiments in their progreſs at any time; and as an attempt ſhould be made in the minutes, to expreſs important points of diſcourſe in the very words of the ſpeakers, and theſe parts were to be marked at the margin with inverted commas, they were requeſted to inſpect and correct them.

MINUTES

OF THE

SECOND MEETING,

ON

SATURDAY, February 1, 1794.

" *Didactic Discourse and Experiments, intro-*
" *ductory to the Proposition formerly intended*
" *for this Evening, viz.*

" *Caloric, whose Parts are repulsive of each*
" *other, combines with divers Bodies.*"

IN the interval between the first and second meetings, some of the Members informed the Experimenter of their objections to the modern Nomenclature, and their desire that it should be adopted no farther than might be requisite to express new subjects and doctrines. Others observed that the intended proposition concerning Caloric, would appear premature to some, and altogether unintelligible

telligible to thoſe who had not very lately purſued the ſtudy of Chemiſtry: it was the opinion of all, that in order to anſwer the purpoſes of the Society, the Experimenter ſhould purſue the didactic form, and introduce the neceſſary parts of the new Nomenclature and the modern doctrines, by eaſy ſteps.

In compliance with theſe wiſhes, the following proceedings took place.

Bodies were arranged in the Chemical order: their moſt ſtriking diſtinctions were exemplified: certain peculiar properties of each of the elaſtic fluids were then ſhewn, in order to diſtinguiſh each from the others. In the mean time, it was repeatedly inculcated, that the ſimpler bodies, or Chemical principles differ, not only in divers obvious properties of their maſſes, but alſo in thoſe of their minuteſt known parts; as mercury differs from lime, or acid from alkali; and that we naturally and properly expreſs our ſenſe of theſe things by ſaying, *there are different kinds of matter.*

Caloric was defined and characterized, as the cauſe of temperatures, of heat, and of the viſible ignition of bodies. By the copious

ous and rapid emiſſion of fire, during the combuſtion of charcoal with nitre, of phoſphorus and iron in oxigen gas, and by a conciſe anticipation of ſubjects hereafter to be illuſtrated; it appeared that Caloric ſubſiſted in great quantity in the coldeſt bodies, and in a ſtate very different from that in which it is the cauſe of temperature or of heat. As acid ſubſiſts in ſea ſalt, in a ſtate widely different from that in which it diſſolves marble, or taſtes ſour, or deſtroys the human organs; ſo it was ſaid Caloric exiſts as a chemical principle of divers ſolid and fluid bodies.

It was argued, on various phyſical grounds, that we have as ſatisfactory evidence of the materiality of Caloric, and of its agency, as a chemical principle different from all others, as we have of other natural ſubjects; and that the diſcoveries of the laſt twenty years, which have ſupplied this evidence, forbid any farther affectation of terms and definitions which were prudently adopted, whilſt experiments were wanting to decide whether fire conſiſts in the mere motion or vibration of the parts of bodies indiſcriminately, or of matter of a peculiar kind, in a ſtate of tran-

ſition

ſition or motion, and cauſing motion in bodies.

The extreme ſubtility of this matter was duly noticed, together with its tendency to expand from central ſources or hot bodies, and to diffuſe itſelf in the manner of an elaſtic fluid; and from a variety of phenomena it was inferred, that its parts repel each other, and by virtue of this repulſion, Caloric is the cauſe of the elaſticity of aëriform fluids.

The agency of this matter towards the expanſion of bodies, was exemplified in divers inſtances and experiments. The extreme inſtances ſhewed the immenſe and indefinite expanſion of ſome bodies, which are formed into gaſes, in temperatures which ſcarcely alter the volume of other bodies, ſuch as the earthy, in any meaſurable degree. From theſe, and the inſtances of bodies expanded in intermediate degrees, in the ſame temperatures, it was inferred that, "divers notions "heretofore entertained on this ſubject were "erroneous; and that the true nature of this "Matter cannot be ſucceſsfully inveſtigated "by thoſe who are inattentive to the attrac- "tive forces called affinities of the parts of "bodies,

" bodies, not only to each other, but to
" thoſe of Caloric."

Attraction was now exemplified, in the different inſtances and circumſtances which have given riſe to the opinion that there are different kinds of attraction.

Chemical attractions eſpecially were illuſtrated by experiments ſhewing their effects, and the gradations of their forces, and explaining the grounds of the tables of elective attractions.

In the courſe of theſe experiments, the important phenomena reſulting from the union of diſſimilar particles, were particularly and repeatedly noticed; and the correct uſe and true meaning of the word *combination* was inculcated. " For the addition and cohe-
" ſion of ſimilar parts do not alter the Che-
" mical properties of bodies. Acid blend-
" ed or aggregated with acid, or alkali with
" alkali, only form larger maſſes of acid or of
" alkali; whilſt the combination of acid with
" alkali produces a new compound, widely
" different in its properties from thoſe of ei-
" ther of the conſtituent bodies. The like
" may be exemplified in thouſands of inſtances.

" This phenomenon, the cauſe of which

" is not now to be confidered, is implied " and expreffed by the word combination; " and the precifion and chaftity of Phyfical " language require that we fhould ufe the " fame term to exprefs the fame thing, whe- " ther it happen to acid or alkali or Ca- " loric.

" As there are gradations of attractive " forces, fo there are of combinations; from " the moft ftriking with acid and alkali, " or with the materials of glafs, down " to that of water in ivory or alum. And " as the term is applicable in all thefe cafes, " fo it is in all analogous conditions of Ca- " loric, however detained by attractive forces " preventing its agency on other bodies."

Inftances of thefe gradations were given, and will occur in the fequel.

The next experiments were made to illuftrate the phenomena of *faturation*, and to fhew that attractive and repulfive powers are generally as the quantities of matter to which they belong.

Muriatic acid gas and ammoniacal gas, being prefented to each other in due proportions, combined and formed a mild neutral falt, in which the caufticity and other cha- racters

racters of the gaſſes, were reſtrained and concealed; a part of the Caloric which gave them the gaſſeous form, being at the ſame time excluded and menſurable by the thermometer. Additional quantities of either gas being then added, did not combine or undergo any alteration.

When the gaſſes were preſented to each other in any other proportions than this firſt taken, they combined in determinate quantities; but the exceſſive part of either remained unaltered.

" When a body has thus received the ut-
" moſt quantity of other matter which it
" can retain in a ſtate of combination, it is
" ſaid to be *ſaturated.*"

" In the reciprocal ſaturations of gaſſes, we
" can eaſily perceive that Caloric is the cauſe
" which prevents indefinite union, and limits
" the quantities combinable. And when we
" duly attend to the affinities of this matter,
" we diſcover the like agency of it in all
" inſtances of ſaturation."

This was exemplified in the mixture of ammoniacal gas and Carbonic acid gas, of nitrous gas and oxygen gas; in abſorptions of gaſſes by water; in combinations of acids

with kali, natron, earths and metals; in all which, considerable quantities of Caloric were liberated from the portions combined, but not from the superfluous portions.

" Thus it appears that the sum of the at-
" tractive forces is as the quantity of attractive
" matter, and the sum of the repulsive forces
" as the quantity of repellent matter; and
" that each particle attracts, or by its Caloric
" repels, with a limited force.

" When the nature and agency of Caloric
" were less known than they are at present,
" it was imagined that the chemical attrac-
" tions ceased at small distances of the parts of
" bodies, and that repulsion there took place;
" whilst the attraction of gravity extended to
" the utmost limits of the universe. But in
" consequence of the later and more success-
" ful investigations of these subjects we learn,
" that attractive powers subsist whether they
" be counteracted or not, and that they cease
" not at any time or distance, although they
" decrease in a high ratio whilst the distances
" increase.

" In ordinary chemical combinations, Ca-
" loric limits the quantities in which the
" grosser particles of bodies can combine and

" cohere,

" cohere, and prevents the portions ſuper-
" added from obeying any attractive force
" except that of gravity. If the word at-
" traction be uſed to expreſs an effect, theſe
" latter are not Chemically attracted, al-
" though they be endued with this power of
" attraction and retain it unimpaired.

" But in regard to the attractions and com-
" binations of Caloric, it is to be remem-
" bered, that there is no other repellent ſub-
" tile matter to regulate or controul them;
" and there is nothing to limit or modify its
" union with bodies, except the repulſion of
" its parts, and the aggregating forces,
" which in uniting the groſſer parts of bo-
" dies, tend to exclude the interceding Ca-
" loric, as will be ſhewn hereafter.

" The general laws of attraction and com-
" bination, and all the known phenomena of
" Caloric, lead us to this inference; that at-
" tractive particles engage around them into
" a ſtate of combination, as much Caloric as
" the mutual repulſions of its parts will per-
" mit to be thus approximated towards each
" other; and alſo engage further portions
" around the former, but with forces and

" denſities decreaſing, as the diſtances from
" the central particles increaſe.

" Although the phenomena ſhew that Caloric of temperature, which in the latitude of ſpeech may be called free Caloric, is rather relatively than abſolutely free; it is not aſſerted, that the Caloric of temperature is combined. But *that* part of the Caloric of a body is ſaid to be combined, which is fixed in it in certain quantity at the loweſt known temperatures, and is reſtrained from acting as Caloric on other bodies. And of this part we affirm that it is truly combined, and is as much a Chemical principle in bodies which may be made to emit it copiouſly and rapidly in combuſtions and other proceſſes, as the earth, Carbo, Oxygen, or any other matter of them.

" Of all that has hitherto been advanced, the main purpoſe is to render the ſtudy eaſy by analogies, to make the terms familiar, and to give a ſuperficial view of the ſubjects to which they relate."

MINUTES

OF THE

THIRD MEETING,

ON

SATURDAY, February 8, 1794.

" *Caloric, whoſe Parts are repellent of each*
" *other, combines with divers Bodies.*"

TO give many inſtances, in a ſhort time, of the tranſition of Caloric from the ſtate of Fire, to that of its combination with bodies, the following Experiments were ſelected for this Evening.

EXPERIMENT I.

A glaſs tube bent in the manner of the letter S, was accurately ground to fit the neck of a glaſs bottle, whoſe bottom was round and thin. The bottle might hold five ounces of water; but the diameter of the bore of the tube was not more than 1-16th of an inch.

 Vitri-

Vitriolic acid, now called the Sulphuric, was diluted with a quarter of its weight of water; and when it was cold, about two ounces of it were poured into the bottle; and in the courſe of ten or twelve hours, ſmall portions of two ounces of ſea ſalt were added at diſtant intervals, until the ſalt ſtood even with the ſurface of the acid. Afterwards the remainder of the ſea ſalt was added at once.

The ſalt was thus introduced, in order that the Caloric liberated at any period, might not be ſufficient to raiſe the temperature of the mixture conſiderably.

All this while, the charge was ſurrounded with water cooled by ice; and the waſte of gas was prevented by ſtopping the bottle with the tube, and by preſſing the mouth of the tube into mercury contained in a mahogany trough like that deſcribed by LAVOISIER.

The charge being thus prepared, and cold and quieſcent previous to the meeting; the bent tube was now advanced under a pint jar filled with mercury and inverted on the ſhelf of the trough. The flame of a ſmall ſpirit lamp being then approached to the bottom of the bottle, the gas inſtantly formed, and iſ-

ſuing

ſuing through the mercury, ſoon filled the inverted jar. It was afterwards directed into others ſucceſſively applied.

During this rapid efflux of gas, the temperature of the charge was but little augmented, and was greatly inferior to that which a non-evaporable ſubſtance would acquire in theſe circumſtances. The gas itſelf had no more than the temperature of the ambient air; and the very ſlender tube, through which four or five pints of gas had paſſed in a continued ſtream, received no ſenſible augmentation of temperature during the experiment.

EXPERIMENT II.

Two ounces of lime well burnt, and one of dry muriat of ammoniac, were ſeparately powdered and quickly mixed; an ounce of ſtrong liquid ammoniac, called aqua ammoniæ puræ, was put into an eight ounce round bottomed bottle placed in iced water. A part of the mixed powder was gradually added, to prevent as much as poſſible the augmentation of the temperature; and when the whole was thickened conſiderably, the remainder of the powder was added. All this was done

with the precaution above described to prevent the loss of gas. When the charge was cold and quiescent, the flame of the spirit lamp was applied as formerly; and the gas, which immediately issued, was directed into jars which had been carefully dried. The temperatures of this charge and of the slender tube, and of the issuing gas, were like those of the preceding experiment.

EXPERIMENT III. and IV.

In the same manner and with the like event, nitrous gas was procured from water charged to greenness with nitrous oxyd and acid: and fluoric acid gas was procured from a charge, consisting of three parts of sulphuric acid, and one of powdered fluor.

As these experiments were made under the same atmospheric pressure, it was deemed unnecessary to consider it on the present occasion, otherwise than as resisting in some degree the extrication and expansion of the gasses.

In the proximity or contact of the parts of these charges in low temperatures, the attractive forces are sufficient to retain them

in their firſt condition : but as all attractive forces decreaſe when the diſtances of the particles increaſe, the heated and dilated charges obey the prevalent power of Caloric, namely, its attraction to the baſes of the gaſſes. Each molecule now compelling its charge of Caloric, and each charge repelling the others, an elaſtic fluid is formed which reſiſts compreſſion, and tends to expand at the loweſt temperature.

During the combuſtion of alkohol with air, a great part of the Caloric which they held in a ſtate of combination, eſcapes from them, and acts as free Caloric or fire. When this pervades the veſſels and the charges, a portion of it is expended in augmenting the temperature; but another portion combines with the baſes of the gaſſes, and forms compounds whoſe properties differ, by the law of combination, from thoſe of the component parts. For the *attractive* parts of theſe baſes now recede from each other, and the Caloric is reſtrained from acting on other bodies, and is as truly combined as cauſtic Soda is in mild ſea ſalt; for ſuch are the ſigns and proofs of every combination.

EXPERIMENTS V. and VI.

Thoſe who have bent their thoughts chiefly on the electric fluid, are apt to entertain a doubt whether that matter may not act in theſe experiments. They were therefore repeated with veſſels of porcelain glazed internally and externally, and bedded in glaſs ſurrounded with ſand in other non-conducting veſſels. The gaſſes were formed in the manner already deſcribed, before the temperature of the ſtrata was raiſed ſo far as to alter their non-conducting character.

In theſe latter circumſtances the charges were not expoſed to the light of the lamp. And as hot water or any heated body anſwered as well as the flame of a lamp, the gaſſeous ſtate was produced and maintained by Caloric only.

In the deſcription of the various gaſſes, and of the circumſtances in which they may be produced, it appeared that Caloric is held by many different kinds of matter in a ſtate of combination and diſtinguiſhable from that of their temperature.

" Whether we trace Caloric from ignited

" bodies

" bodies into the compofition of gaffes; or
" from its combinations in fuch bodies as
" gunpowder or lime, to the ftate of Caloric
" of temperature, or of Fire; and however
" we attempt to inveftigate this fubject;
" the matter of Light prefents itfelf to
" us at every ftep, creating doubts and
" difficulties.

" It is therefore expedient for a while to
" avoid as much as poffible every confidera-
" tion of the Light emitted during the com-
" buftion of gaffes or bodies; but at the fame
" time to admit the terms adopted by the
" Experimenter, under an opinion enter-
" tained for many years, and publifhed in
" 1786. This opinion will be tried by va-
" rious pre-conceived experiments in the
" courfe of thefe meetings, and by fuch other
" means as fhall be fuggefted; and is as fol-
" lows.

" It does not in any inftance appear that
" the matter of Light differs from that of
" Caloric or Fire. The legitimate inference
" from all the known phenomena is, that
" Caloric caufes heat by its quantity, and
" illumination by fuch parts as have ac-
" quired a rapid projectile motion."

The

The following experiments exhibited further evidence of the combinations of Caloric.

EXPERIMENT VII.

A gallon of ammoniacal gas, and the quantity of marine acid gas neceſſary for reciprocal ſaturation, were made to mix quickly in an intermediate ſmall and thin glaſs veſſel, exhauſted of air. A white thick fume was inſtantly formed from the gaſſes, and ſoon converted into a ſalt adhering to the ſides of the veſſel. The Caloric excluded during the approximation and union of theſe baſes of the gaſſes, reſumed its former characters of free Caloric, and heated the veſſel very ſenſibly to the touch. It was obſerved, that, when a few grains of the gaſſes can thus heat a veſſel of this weight during the union of their baſes, it can be proved by experiments hereafter to be exhibited, that the liberated Caloric was in quantity ſufficient to maintain a vaporous ſtate of the ſalt thus formed, or to make it almoſt red hot, if the expanſion of it were prevented.

EXPE-

EXPERIMENTS VIII. IX. X.

Mixtures of Ammoniacal with Carbonic acid gas, of ſulphureous with Ammoniacal gas, of Nitrous with oxygenous gas, made in the ſame way, afforded the like phenomena, and the like inferences in regard to Caloric.

It was obſerved that all experiments with gaſſes which exhibit theſe phenomena independently of atmoſpheric preſſure, prove that the parts which attract each other to combination, attract at all known diſtances of them; for otherwiſe their charges of Caloric would prevent their approximation and union. "By general analogy, and by the "evidence of divers phenomena which will "hereafter be noticed, we are led to con-"clude that particles which are combin-"able with Caloric, attract diſtant as well "as contiguous portions of it; but the latter "with the greater forces."

EXPERIMENT XI.

A cylindrical glaſs veſſel open at bottom and having a neck like that of a phial, was fitted to a glaſs tube. The tube was bent to a right angle at the height of four inches from the neck, and in this part was provided with a ſtop cock. At the diſtance of ſix inches from the firſt flexure, it was bent again, ſo that the ends were parallel with each other. One end of this tube was fixed in the neck of the veſſel, the other end entered a ſmall bottle and went nearly to the bottom of it, where mercury was placed in ſufficient quantity to ſtop the mouth of the tube. Over the mercury an ounce of water was introduced. When the cylindrical veſſel was filled with four or five quarts of the muriatic acid gas formerly deſcribed, at the temperature of ſixty, it was ſlidden from the ſhelf to the deepeſt part of the mercurial trough. The cock being now opened, and the cylinder ſtrongly preſſed into the mercury, the gas was forced quickly into the water, which

ab-

abſorbing it greedily, was heated together with the bottle and the mercury, by the diſengaged Caloric. " When this experiment is " made on a larger ſcale, the heat exceeds " 160 degrees."

In this caſe the ſmall weight of the gas in compariſon with that of the bottle mercury and water, is to be conſidered in the eſtimation of the quantity of Caloric liberated during the abſorption.

EXPERIMENT XII.

The like meaſure or a larger of ammoniacal gas, being preſented to water under ſimilar circumſtances, exhibited the like phenomena of abſorption and heat.

EXPERIMENTS XIII. XIV.

To make theſe experiments impreſſive without the aid of computation; a retort, whoſe neck was ſlender and elongated to three feet, and which had been previouſly charged with four pounds of the quieſcent mixture of acid and ſalt deſcribed at page 23 was quickly bedded in hot ſand to the height

of the charge; the extremity of the neck being at the ſame time immerſed deeply in four ounces of water in a bottle caſed with woollen cloth. The poſition of the retort was ſuch that the heat of the ſand did not reach to the neck. As ſoon as the body of the retort touched the hot ſand, the gas began to iſſue: Afterwards it iſſued rapidly, and in a few ſeconds made the water, now charged with acid, ſcalding hot. Freſh charges of cold water were repeatedly applied in the ſame way, and heated to the deſcribed degree; after which the eſcape of gas and vapour prevented any farther augmentation of the temperature of the liquor.

The quieſcent charge of lime ammoniacal ſalt and water deſcribed at page 25, being uſed in this great quantity and treated in the ſame way, afforded the like appearances.

In both experiments the lengthened necks of the retorts, except thoſe parts which were within three or four inches of the hot ſand and the heated water, were as cold as the ambient air.

In both experiments alſo, a piece of glaſs was placed near each retort at the depth of the center of its charge, and theſe pieces yielding no baſe of a gas to engage the Caloric,

ſoon

ſoon acquired the temperature of the hot ſand, whilſt the gaſſes iſſued as cold as the ambient air, and the ſides of the veſſels, where they tranſmitted Caloric from the ſand, had an intermediate temperature.

" Theſe are only a few of the many in-
" ſtances in which the Caloric traced from
" hot bodies into the compoſition of gaſſes,
" may be exhibited again in the ſtate of Ca-
" loric of temperature or free Caloric, by
" the means of water and other bodies which
" attract and condenſe the baſes of the gaſſes:
" but it is to be obſerved that in ſuch in-
" ſtances the whole of the combined Caloric
" is not liberated.

" As to the gaſſes which thus act on each
" other ſpontaneouſly, or enter water to the
" excluſion of the deſcribed quantity of Ca-
" loric; it is to be remarked, that their cen-
" tral parts are not ultimate particles, but
" that they conſiſt of two or more particles
" of different kinds combined and encom-
" paſſed with Caloric.

" The Carbonic acid gas, for inſtance, con-
" ſiſts of combined particles of carbo and oxy-
" gen, or of Molecules engaging their charges
" of Caloric. The ammoniacal gas conſiſts of

 " central

" central particles of Hydrogen and Azot
" combined and charged with Caloric. The
" molecules of theſe gaſſes are conſequently
" attracted by compounded and co-operating
" attractive forces, by the prevalence of which
" they are, when preſented to each other,
" combined to the excluſion of Caloric.

" But there are gaſſes, whoſe baſes have
" not hitherto been decompoſed, or found to
" conſiſt of more than one kind of matter.
" Such baſes are Azot, Hydrogen and Oxy-
" gen; each particle of which engages Ca-
" loric on all ſides. Theſe gaſſes pre-
" ſented to each other in any proportions,
" will not combine to the excluſion of any
" part of their Caloric, until ſomething is
" done to blend the charges of it.

" Thus we perceive that the attractive
" forces of their ſmaller or uncompounded
" central parts, are inſufficient to over-
" power the agency of their charges of Ca-
" loric, and that this is perfectly conſiſtent
" with the genal law for the limitation of
" ſuch attractive powers.

" It is not neceſſary at preſent to enquire
" how a ſpark applied to any quantity of
" hydrogen gas mixed with about half its

" bulk

" bulk of oxygen gas, is inſtrumental in the " inſtantaneous combuſtion of them; and " we need only attend to the phenomena of " the combuſtion, which afford a ſplendid " proof of the propoſition before us."

EXPERIMENT XV.

A glaſs tube, whoſe cavity was cylindrical, 36 inches in length by $1\frac{1}{2}$ in diameter, and whoſe ſides and cloſed end were more than a quarter of an inch in thickneſs; was pierced with two ſmall holes oppoſite to each other, and near the ſealed end of the tube. Two ſmall blunted needles of braſs were accurately ground to ſtop theſe holes completely, when their ends were diſtant by 1-16th of an inch, near the axis of the cylinder.

This tube being heated and filled with hot quickſilver in the manner of a barometer, in order to exclude the air entirely, was ſuſpended perpendicularly, ſo that its mouth ſunk five inches in the mercury of a long and deep trough. The inſtrument by which it was thus ſuſtained, admitted a recoil of half an inch or more, in order to divide the intended ſhock.

One ounce meaſure of hydrogen gas mixed with half this bulk of oxygen gas was gradually introduced through the column of mercury, which conſequently ſubſided. The inaccuracies of meaſures, and other circumſtances required that ſuch a mixture ſhould be tried and ſupplied with as much of either gas as was found neceſſary for the intended ſaturation. An electrical circuit being now prepared by wires hooked in the needles, a ſpark was taken between their points in the mixed gaſſes. In the ſame inſtant a bright and tranſitory flaſh filled the whole capacity of the tube above the mercury, and in a moment the mercury returned nearly to its former height, or to the height at which atmoſpheric preſſure could ſuſtain it in the preſence of water, which now bedewed the inner ſurface of the tube, and in this circumſtance yielded aqueous vapour.

The change in the gaſſes, the union of their baſes, and the manifeſt eſcape of the Caloric which formerly maintained their gaſſeous ſtate, ſerved to confirm the foregoing inferences concerning Caloric and the combinations of it.

" But this and all rapid combuſtions ſug-

" geſt

" gest other notions of equal importance: " for they indicate that Light, like Caloric, " consists of repellent parts which are com- " binable with bodies; and that the differ- " ence between them may consist rather in the " motion than the matter.

" They moreover intimate the circum- " stances in which the Caloric of a solid body " or of a gas may, when extricated, act as " Caloric of temperature, or as fire and " Light, according to the velocity with " which it is excluded and propelled, and " the media which are opposed to it."

After the Experimenter had concluded, a conversation took place, in which Mr. Young " objected to the use of the term " combination to express the mode in which " Caloric is present in gasses and other sub- " stances; thinking it inconsistent with that " system of the capacity of bodies for heat " which has been very ingeniously supported " by Dr. Crawford. He observed that a hot- " ter body will at all times communicate to a " colder one, a quantity of Caloric proporti- " onal to the whole Caloric contained by the " hotter, and to the capacity of the colder for " receiving it. He mentioned an experiment

" of Dr. CRAWFORD which ſhews that wa-
" ter will communicate to mercury or oil
" of turpentine ten degrees colder than itſelf,
" a greater quantity of Caloric than an equal
" bulk of ice will give over, under ſimilar
" circumſtances; from which it would ſeem
" that the Caloric abſorbed by water in
" thawing and ſo readily ſeparable from it,
" is not, properly ſpeaking, combined. Mr.
" YOUNG alleged that preſſure will force
" out a portion of Caloric, and that dila-
" tation will enable a gas to abſorb an ad-
" ditional quantity. That ſince it was al-
" lowed that a certain quantity of heat ſub-
" ſiſts in a body in an uncombined ſtate, it
" was ſimpler and therefore more philoſo-
" phical to ſuppoſe the whole Caloric pre-
" ſent to be in the ſame circumſtances: and
" when a body changes its ſtate from ſoli-
" dity to fluidity, that it might be compared
" to a veſſel enlarged in capacity, but ſtill
" remaining open:—In ſhort that Caloric
" was retained in bodies more like water in
" a ſponge than water in a chryſtal: and
" that if this idea was conſiſtent with the
" word combination, he would not much
" object to the term, eſpecially after the ex-
" planation

" planation which the Experimenter had
" delivered; provided that the peculiarities
" of this union and its differences from
" common chemical combinations were kept
" in view."

Lord STANHOPE argued with great force in ſupport of the combinations of Caloric; he adverted to the grounds on which a contrary opinion had been maintained; and in regard to Mr. YOUNG's reaſoning, he obſerved "that it was admiſſible only in reſpect to
" condenſible vapours and Caloric of tempera-
" ture generally; but not at all in reſpect to
" the gaſſes."

Dr. LATHAM made ſeveral ingenious obſervations in reply to Lord STANHOPE; but they were not inſerted in the minutes.

" Mr. YOUNG endeavoured to prove, in
" anſwer to Lord STANHOPE, that the diſ-
" tinction between gaſſes permanently elaſ-
" tic and gaſſes or vapours not permanently
" elaſtic was only imaginary, and even ac-
" cording to LAVOISIER's opinion, acciden-
" tally derived from the circumſtances of
" preſſure and temperature under which they
" are ſubmitted to our examination."

He

He concluded by deſiring that the following queſtion be inſerted in the minutes.

"Does Caloric ever enter into combination with other matter, in a manner ſimilar to the chemical combinations? Or is it ever perfectly latent?"

Mr. DEVAYNES made ſome obſervations which were well received, and concluded with propoſing the queſtion to be decided by experiments, "Whether Caloric has weight?"

MINUTES

OF THE

FOURTH MEETING,

ON

SATURDAY, February 15, 1794.

THE propofition of the laft meeting remained on the tablet.

The members were conducted to different furnaces in which the experiments were carried on; and thefe were explained by the affiftant experimenters.

Afterwards the Experimenter expreffed his refpectful attention to the arguments of the members who fpoke at the laft meeting, and his intention to difcufs the fubjects of them in due time.

He then proceeded as follows.

" When the proper bafis of a gas is firmly
" combined in any body, the agency of the
" Caloric of low temperatures is not fuffici-
" ently forcible to overcome the combining
" powers.

" powers. So ſea ſalt may be heated melt-
" ed and evaporated, without any extrication
" of its acid, and without forming any gas.
" But when we apply ſulphuric acid to ſa-
" turate the alkaline baſis of the ſalt and
" diſlodge the marine acid, by prevalent elec-
" tive attraction; then the latter acid in its
" liberated ſtate, combines with Caloric,
" aſſumes the ſtate of gas and maintains it at
" the loweſt natural temperature.

" The like obſervations apply in all the
" inſtances in which we facilitate the extri-
" cation of gaſſes by additional ſubſtances or
" common Chemical agents; as when we
" apply lime to muriated ammoniac, in or-
" to produce ammoniacal gas.

" Each of the *Chemical* principles of this
" muriated ammoniac, namely the muriatic
" acid and the ammoniac, is capable of form-
" ing a gas in low temperatures: but the
" molecules compoſed of theſe cannot, for
" the reaſon formerly aſſigned, hold Caloric
" in ſufficient quantity to maintain the gaſ-
" ſeous ſtate, but are compelled by their
" compounded attractions to form aggregates.

" The aggregate of ammoniacal ſalt may
" be melted, and by a greater heat may be

" thrown

" thrown into vapour, without undergoing
" any decompoſition. The vapour in cool-
" ing concretes into a ſolid maſs, ſuch as
" that which is uſed to yield ammoniacal
" gas, when its acid is engaged by another bo-
" dy; and acid gas when its ammoniac is in
" like manner engaged.

" In tracing the attractions and combina-
" tions of Caloric, it is expedient in the next
" place to ſhew their gradations, in experi-
" ments which require nothing more than
" the mere agency of Caloric."

EXPERIMENT I.

Martial vitriol, now called ſulphat of iron, when duly prepared and freſh, was ſaid to conſiſt of 55 of water, 20 of acid and 25 of metal, in 100 parts of the ſalt.

When this ſalt was quickly heated in a cloſe veſſel provided with a recipient, the firſt effect of the Caloric was to expand and liquify it. The ſuperadded portions of Caloric were engaged by the water of the ſalt, and expended in forming it into vapour.

To proſecute the experiment conveniently,

ently, a porcelain retort charged with two pounds of the ſaline maſs which remained after the expulſion of the water, was placed in a wind furnace; a recipient was luted to the elongated neck of the retort, and to the recipient was fitted the apparatus of Mr. Woulfe deſcribed in Lavoisier's Elements of Chemiſtry, and contrived to ſave and exhibit the various products.

When the heat was gradually augmented, to exceed that at which the chief part of the water was expelled, the laſt portions of water paſſed off accompanied with ſulphuric acid vapour which condenſed in the recipient. During the diſtillation of the Sulphuric acid, ſulphureous gas iſſued in quantities gradually augmenting.

After the water in the firſt bottle had abſorbed the ſulphureous gas until it was ſaturated, the other bottles in ſucceſſion abſorbed more, until all the water employed was ſaturated.

When the emiſſion of the gas became very ſlow and might be ſaid to have ceaſed, notwithſtanding the red heat of the retort; and when it was obſerved that a ſtronger fire muſt be employed, for the extrication of any

re-

remaining basis of a gas, the recipient was removed, and the elongated neck of the retort was made to deliver the subsequent gas into bottles in the usual manner.

The fire in the furnace being now encreased, so as to make the retort glow at last with a white heat, the product was oxygen gas in considerable quantity; the first portions of which were of course accompanied with a little of the residuary acid, but those which followed were pure, or nearly so. The matter remaining in the retort was found to be oxyd of iron slightly magnetic, and consequently retaining but a small quantity of oxygen.

" In this experiment we see a solid body, " not only expanded but resolved into many " products of different kinds by the agency " of Caloric; and we see the same Caloric " producing different effects on the different " products according to their affinities.

" The aqueous part of this saline com- " pound is first formed into vapour; whose " elasticity in vessels which cannot retain " free Caloric, shews that the aqueous mole- " cules engage charges of Caloric around " them; and whose subsequent condensation

" shews

" ſhews that the attractive powers which
" form the charges, are weaker than thoſe
" which tend to the diffuſion of the Caloric
" and the re-union of the molecules, firſt to
" form water and then at a lower tempera-
" ture to form ice. The ſulphuric acid is
" detained until the agency of Caloric is
" augmented by the higher temperature: it
" is then formed into vapour, whoſe elaſti-
" city and ſubſequent condenſation afford the
" like inferences.

" The ſulphureous acid follows next, when
" urged by Caloric in a higher temperature.
" But as its parts retain charges of Caloric
" with forces ſufficient to overpower thoſe
" which tend to the diffuſion of Caloric and
" the re-union of the acid particles, the gas
" now formed maintains its elaſticity under
" any preſſure or ordinary temperature. So
" does the oxygen gas, whoſe baſis adher-
" ing moſt firmly with iron, is extricated the
" laſt, by combining with Caloric and form-
" ing oxygen gas."

EXPERIMENT II.

In the next experiment a glaſs retort was charged

charged with thirty-four ounces of dry white nitrat of mercury, consisting of twenty-four of mercury and ten of acid. The retort was coated with a composition of one measure of Sturbridge clay finely powdered, four measures of coarse powder of Potters Ware made of Sturbridge clay and baked, and one measure of Tow cut into short filaments; all well mixed and then moistened to form a plastic paste with water. The whole mass was applied first to the bottom of the vessel, and was then pressed and extended to an equal thickness over the sides and helm. For when a coating is made with several pieces, it is apt to crack in the junctures during the drying.

The retort was placed on the sand bed of a reverberatory furnace, with the whole of its long slender neck projecting out of it. A recipient previously ground to the neck of the retort was fitted to it, and a tube ground into the upper part of the recipient, was bent so as to deliver any elastic fluid passing through it, into water, and through a funneled shelf into inverted bottles.

When the charge was sufficiently heated, a thick red acid vapour arose, and passing into the recipient, was very slowly condensed by

the aid of iced water. Of the nitrous gas which was formed and expelled about the ſame time, a part was condenſed in the acid which it coloured highly, the remainder paſſed off permanently elaſtic. The quantity of nitrous gas relatively to that of the condenſed acid, augmented gradually until about eight ounces of both were expelled, and the laſt portions conſiſted entirely of nitrous gas.

A longer continuance of the ſame heat produced no further effect. The maſs, which was now red oxyde of mercury, retained the oxygen which belonged to the baſis of the nitrous gas, and ſuſtained this heat of about ſix hundred degrees without any decompoſition.

The recipient being removed, the mouth of the retort was made to enter the water obliquely under the funneled ſhelf. The fire was raiſed gradually until the coating began to grow red. Oxigen gas now iſſued quickly or ſlowly according to the ſtate of the fire in the furnace, and was received in bottles: In the mean time a ſlender ſtream or ſucceſſive drops of Quickſilver trickled down into the water. When the retort had cooled, not a particle of mercury or oxyde re-

remained in it. The neck of the retort, ſhewed a film of mercury adhering to it and ſilvering it. It was obſerved that when this operation is haſtily performed, the guſt of oxygen gas carries with it a little of the mercurial oxyd in fine powder which entangles a film and ſmall globules of mercury near the helm.

" Throughout this operation as well as " the laſt, Caloric manifeſtly acts as a Che- " mical principle in regard to the baſes of the " gaſſes, and combines with them.

" The Chemical principles of nitrous acid, " namely the nitrous baſe and oxygen, are " each capable of combining with Caloric " and of forming diſtinct gaſſes. Theſe " when preſented to each other, combine " ſpontaneouſly and form nitrous acid; " excluding in the mean time a great part " of their combined Caloric. Hence it hap- " pens, that a conſiderable quantity of ni- " trous acid, whether it be expelled in the " form of acid vapour, or in the ſtate of " gaſſes, condenſes ſlowly in the recipi- " ent. But as the oxygen adheres moſt " firmly to the mercury, and cannot be " expelled from it by any heat under ſe-

" ven hundred degrees, all the nitrous base
" which belonged to this part of the
" mercurial oxyd, passes off in the lower
" temperatures in combination with Caloric
" and thus forms the nitrous gas.

" Although the acid be maintained in
" the state of vapour in high tempera-
" tures, it condenses at the lower, by the
" attraction of its parts and the diffusion
" of the Caloric to colder bodies. The
" mercurial vapour condenses by the like
" means in the cold neck of the retort.
" But with the nitrous base and the oxy-
" gen, Caloric combines and forms gasses
" permanently elastic at the lowest na-
" tural temperatures.

" In consequence then of the gradations
" of the attractive forces, the Caloric acts
" differently on the different subjects, and
" combining with some whilst it evapo-
" rates others, it resolves the solid salt
" into four distinct bodies, namely mer-
" cury, nitrous acid, nitrous gas, and ox-
" ygen gas.

" That Caloric is combined in these
" gasses, and is the cause of their elasti-
" city we learn by general analogy, as
" well

" well as by the following obſervations. " Whilſt nitrous gas iſſues accompanied " with little or no condenſible acid, it " paſſes cool through the ſlender long neck " of the retort, from a charge in which " the heat is 550 or 600°: The oxygen " gas likewiſe paſſes cool from the red hot " oxyde. If the two gaſſes be further cool- " ed in iced water, and then mixed in an " intermediate veſſel in the proportion of " two gallon meaſures of nitrous gas to " one of oxyen gas, they form nitrous acid. " The Caloric excluded in the mean time, " heats the neighbouring bodies, and ſhews " that it was in a ſtate of combination " around the diſtant parts of the gaſſes; " for otherwiſe this Caloric of the ſeveral " gaſſes would have diffuſed itſelf to the " iced water, or be diſcoverable by the " uſual characters of Caloric of tempe- " rature.

" The quantity of Caloric emitted on " this occaſion, is greater if the veſſel be " wet with water: for it is the nature of " mere nitrous acid and of nitrous ſalts to " retain Caloric in great quantity and inti- " mately combined."

EXPERIMENT III.

In the next experiment, a porcelain retort was charged with pure dry acetat of lime, the neck was elongated by luting a conical glafs tube to it; and to the extremity of this tube, the apparatus for faving the condenfible and elaftic products was fixed with glue lute.

Glue lute is made with powdered lime and liquid glue, fuch as carpenters ufe, quickly mixed to the confiftency of pafte, and applied whilft warm, between the junctures, rather than upon them. It fets quickly, rather fwells than contracts, and foon becomes impervious to air.

The acetat of lime having been long expofed in a heat of 212, had no fmell of acetic acid, and confifted of 1586 grains of lime, and 2379 grains of acid. It was expofed to heat in the manner of the former experiment.

In confequence of the gradual action of the fire on this falt, until the retort was red hot, the acid was decompofed, and by the

union

union of ſome of its principles with Caloric, was reſolved into the following products. Azotic gas, Carbonic acid gas, Carbonated Hydrogen gas, Æthereal oil, Carbo and Calcareous earth.

The Azotic gas paſſed off chiefly with the firſt portions of the gaſſes, and its quantity was comparatively ſmall.

The Carbonic acid gas and the carbonated hydrogen gas paſſed together, without uniting; the mixed elaſtic fluids conſiſting chiefly of the latter towards the end. The condenſible Æthereal oily vapour paſſed off from the beginning, and during the predominance of Carbonic acid gas in the products.

The reſidue in the retort conſiſted of lime combined with carbonic acid, and charged with carbo to blackneſs.

Diluted marine acid applied to this coaly matter expelled the remaining carbonic acid, diſſolved the lime and carried it through a filter, leaving the Carbo behind.

As the purpoſes of the experiment, did not require any correct menſuration, it was deemed ſufficient to ſay that the proportions were not far diſtant from the following:

	Grains.
Carbonic acid gas - - - - -	350
Carbonic acid retained in the lime	850
Carbonated Hydrogen gas - -	600
Æthereal oil - - - - - -	300
Carbo fixed in the lime - -	120
Azotic gas computed at - -	50
	2270
The aqueous matter ſaved, together with that which followed the gaſſes, and was not meaſured was eſtimated at - - - - - -	109
The weight of the acid originally employed, being - - - -	2379

Throughout this proceſs, the gaſſes iſſued cool, even when the charge was red hot.

Thus by the affinities of Caloric and the gradations of them, the ſolid ſalt was reſolved into many different Chemical bodies, ſome holding it weakly or in ſmall quantity, whilſt others held it firmly combined.

EX-

EXPERIMENT IV.

Proper portions of the various products of this operation being put together, namely the black earthy residue, and the three different gasses, at the ordinary temperature of the air; no union of them took place, nor appeared in many hours to be effected. On the contrary the Caloric maintained its combinations in opposition to the attractive forces which formed the salt; and due portions of the oily and aqueous liquors did not serve to unite the products in any considerable quantity.

EXPERIMENT V.

Equal measures of the carbonated hydrogen gas and of oxygen gas being mixed, they maintained their respective bulks in consequence of the union of each with its Caloric; but on the application of an electrical spark they flamed, emitted Caloric, and formed carbonic acid gas and water.

The carbonated hydrogen gas used in this

combuſtion, was previouſly purified from the carbonic acid gas, by agitation with lime water, which quickly abſorbed the latter, but not the former.

All the inferences of the former experiments concerning Caloric, apply in theſe laſt, and are the more ſatisfactory as they appear in the greater number of different gaſſes and products, to be conformable to the general analogies of nature.

" As the earthy reſidue of the third expe-
" riment conſiſts of lime and carbonic acid,
" with a little Carbo ſcarcely worth notice,
" and as this acid certainly attracts Caloric,
" nothing but its forcible attraction to lime
" prevented it from forming gas, and paſſing
" off with the Caloric, in the red heat to
" which it was ſo long expoſed.

" In other words we expreſs the ſame thing
" ſaying, that the agency of the Caloric of
" this temperature is not ſufficiently power-
" ful to overcome the attraction of lime to
" the ſaturating acid. But as the denſer Ca-
" loric of higher temperatures, acts more
" powerfully to expand bodies, to diſunite
" their parts, and to weaken their attractions
" by encreaſing their diſtances, and at the
" ſame

" ſame time aſſiſts by its preſſion to compel
" and condenſe Caloric around theſe parts;
" nothing is neceſſary towards the total ex-
" pulſion of the carbonic acid and the conſe-
" quent formation of it into gas, but a
" due augmentation of the temperature; as
" the following experiment will ſhew,

EXPERIMENT VI.

A porcelain retort whoſe neck was long and ſlender, was charged with a quantity of black earthy matter equal to that of the laſt experiment; and the mouth of the retort was inclined into water ſo as to deliver the products in the manner formerly mentioned. Nothing beſides the gaſſes which ſtood in the neck of the retort and in the interſtices of this charge iſſued, until the retort was heated beyond the higheſt temperature of the laſt diſtillation. As the fire was increaſed during four hours until the retort glowed with a white heat, the whole of the carbonic acid was expelled in the form of gas accompanied with a ſmall quantity of inflammable gas. When the emiſſion ceaſed and the veſſels were

cool, the residue was found to be perfect lime, coloured slightly grey by the residuary Carbo. Some allowance being made for the parts which touched the retort and adhered by vitrification, the weight of the lime corresponded with that which was originally employed in the composition of the salt. In the efflux of the elastic fluids from the glowing charge, the long neck of the retort was not sensibly heated, beyond the place to which the heat of the bricks extended.

The residuary mass consisting of spongy fragments of lime, was placed when cold in a vessel filled with the gas which had been expelled from it and dried; but did not in the course of several days resume any of the gas.

EXPERIMENT VII.

Another retort was in like manner placed, being previously charged with dried fragments of purified chalk, called whiting. The elastic product of this charge was passed sometimes through mercury and at other times through water; but invariably consisted of

car-

carbonic acid gas mixed with an inconſider-able quantity of Azotic gas.

Sixteen ounces troy of whiting were thus reduced to about nine or leſs of lime void of carbonic acid, and ſeven ounces of carbonic acid were formed into gas and expelled.

Little or none of the Carbonic acid gas iſ-ſued until the retort was red hot; a d the rapid efflux of ſo much gas from the reddened or the glowing charge, never heated the ſlen-der long tube through which it paſſed. This Lime expoſed like the former to the gas of this experiment did not combine with any part of it.

Here the inferences formerly made relative to the agency and combinations of Caloric, were drawan into cloſer order; and many in-ſtances were enumerated with the two laſt, to ſhew that the aggregations which reſiſt the expanding powers of Caloric in low tempe-ratures, are weakened in higher, and are overpowered in ſtill higher; in which laſt Caloric acting with increaſed denſity and energy, envelopes the parts which it attracts, combines in certain quantity, is relatively or weakly engaged in a further quantity; and as to the remainder, expands into neighbouring bodies and ſpaces to form an equilibrium.

The

The relative engagements of Caloric were thus explained. " In a ſyſtem of particles " expoſed to Caloric, whoſe parts repel each " other, the extreme tenuity of the parts of " Caloric is to be conſidered. Expanding " from any central ſource, it pervades gradu- " ally but not inſtantly any number of the " moſt compact veſſels of glaſs, metal or other " materials. If Light conſiſt of nothing " more than particles of Caloric ſuceſſively " projected and moving with immenſe velo- " city, and acting as Fire wherever they are " ſtopped and accumulated in due quantity; as " in bodies placed in the focus of a lens, the " free and rapid paſſage of light through " media which ſtop all other matter, ſhews " ſtill better the extreme ſmallneſs of the " parts of Caloric.

" According to the eſtabliſhed laws of at- " traction and motion, the heavier and groſſer " particles of bodies which attract Caloric, " muſt compel its ſmaller particles around " them; and we are not yet acquainted with " any thing that can limit the quantities " which they can ſeverally draw into cloſe " union or approximation with them, ex- " cept the repulſive nature of the parts of

" Ca-

" Caloric relatively to each other, or its
" attraction to other bodies.

" The obvious consequence of such natural
" powers and laws is this. The grosser and
" heavier central particles severally engage
" Caloric around them, combining with
" a certain portion, and drawing the re-
" mainder of their respective charges into the
" form of atmospheres decreasing in density
" as the distances from the central particles
" encrease. So the earth carries the like
" atmosphere of air, and electrified bodies
" maintain their electrical atmospheres.

" In this condition of particles attracting
" such atmospheres, and consequently retain-
" ed in them, the repellent and receding
" atmospheres carry with them their central
" particles, until the expansion of the elastic
" fluid thus constituted is stopped by some
" contrary power. This notion agrees with
" the phenomena, and serves to explain ma-
" ny which are otherwise inexplicable.

" These things being considered, it will
" appear that in a gas of any kind, the den-
" sity or quantity of each little atmosphere
" of Caloric, will depend on the temperature
" of the gas, or on the density of the Ca-

" loric

" loric impelled upon it. For by a general
" law, which will preſently be conſidered,
" the preſſion of the denſer Caloric of higher
" temperatures, co-operates towards the for-
" mation of denſer or deeper atmoſpheres.

" From the manifeſt attractions of Calo-
" ric; from the general law by which diſſi-
" milar particles not only unite but combine;
" from the agency of Caloric as a Chemical
" principle in decompoſitions and combina-
" tions; from the manifeſt ſuppreſſion of its
" proper characters in theſe combinations;
" and from the recited characters of the
" elaſtic fluids; we learn, that a portion of
" their Caloric is combined, whilſt more is
" concentrated and engaged by weaker at-
" tractive forces; and that the quantity of
" this laſt eſpecially, varies with the preſ-
" ſion of the Caloric of temperature; every
" augmentation of which tends to encreaſe
" the volume and elaſticity of gaſſes."

Whilſt the members were reviewing the operations at the furnaces, divers converſations aroſe, ſome of which were to the following effect.

In the preparation of lime, Caloric combines not only with the Carbonic acid to form the gas, but with the refiduary earth alfo, to form lime. The uncombined mere calcareous earth is not known.

Without awaiting the experiments and inftruments by which the quantities of Caloric are meafured, we can eafily difcover that it enters largely into the compofition of lime. For, not to fpeak of the effect of acids on this Earth, the mixture of water with lime in equal quantities, produces heat enough to form the greater part of the water into vapour, and to make the flaking lime almoft red hot; for if the lime be heaped againft a boarded partition containing iron nails, and be duly flaked in this fituation, it will heat the nails fufficiently to inflame the boards.

As Caloric can feparate the whole of the Carbonic acid from the Earth, and prevent their re-union; and as water tends to exclude Caloric from lime and carbonic acid gas; it feems that the agency of water towards promoting the union of carbonic acid gas or its bafe with lime, depends on the mere exclufion of the predominant Caloric.

The grey or yellowifh colour of lime that

has been prepared in compact porcelain veſſels, and cooled without expoſure to air, is owing to a ſmall quantity of oily or carbonaceous water contained in the chalk or lime ſtone. This avails nothing, in any of the ordinary uſes of lime, and is burned out in the common manufacture of it.

Towards the perfection of lime for Chemical uſes, it is neceſſary that the carbonic acid be totally expelled from it by a ſtrong fire.

If the chalk or lime ſtone contain argil or gypſum, which often happens, it will not afford good lime, becauſe it will undergo ſome degree of vitrification by the neceſſary heat, in proportion to the quantity of theſe impurities.

Lime may be kept for years unaltered, in glaſs veſſels ſtopped with ground glaſs ſtopples; but will ſlake in a few months in bottles covered with many folds of bladder, or with any thing that is pervious to moiſture, and in ſlaking will imbibe carbonic acid along with the moiſture from the air. Therefore it is more neceſſary towards the preſervation of lime, to exclude the moiſture, than the air or any carbonic acid gas which may accompany it; for neither of theſe

laſt

laſt will alter the lime whilſt it remains perfectly dry.

As mortar ſerves to cement bricks in building, lime ſerves to cement the grains of ſand, which conſtitute the baſis of the mortar, with each other and with the brick or ſtone.

The lime ſlaked by the water, drinks in Carbonic acid gas greedily from the air, whilſt the water exhales; and the mortar becomes indurated, not by mere exſiccation, but by the acceſſion of that matter which ſupplies the place of the water, and contributes to the cryſtallization of the calcareous cement. Thus mortar approaches daily to its utmoſt induration, but without any ſhrinking of the walls; except in buildings haſtily erected, and ſo high, that the ſuperincumbent preſſure ſqueezes out the mortar, before it has acquired any ſolidity. In the beſt and oldeſt cements of this kind, it appears that every 100 parts of lime have imbibed ſixty of carbonic acid.

Towards the perfection of a calcareous cement for building, or for incruſtations in the manner of ſtucco, the following things are neceſſary.

The ſand, which is the hardeſt moſt inſoluble and durable part of it, ought to make

the chief part of its bulk; and to this end it ought to be free from clay and other impurities, and be of the kind called ſharp ſand: that is to ſay, inſtead of conſiſting of grains bounded by curved ſurfaces, or of rounded grains which leave the larger interſtices, it ought to have its ſurfaces flat and capable of being cemented together by the ſmaller quantity of calcareous matter. To this end alſo coarſe ſand ought to be mixed with as much fine as will fill its interſtices without encreaſing its bulk. This quantity of fine ſand is about 1-6th of the bulk of the coarſe.

Chalk being a friable ſpongy body, when it is but ſlightly burned or deprived of a part of its Carbonic acid imbibes water and flakes freely; and the flaking being the criterion of the builders, the manufacturers of chalk lime content themſelves with giving the heat and time neceſſary for making it ſaleable.

Limeſtone being much more compact will not flake freely until it has loſt more of its carbonic acid. The greater heat applied for this purpoſe, and the time neceſſary for conſuming the greater quantity of fuel which is thrown in with the limeſtone, inſure a more per-

perfect calcination: Hence in the common courſe of trade, ſtone lime is better than chalk lime. But if they be equally diveſted of the carbonic acid, they ſerve alike for the compoſition of good mortar.

One part of perfect lime, ſlaked after it has been weighed, with lime water inſtead of common water, is ſufficient for five of the blended ſands.

The mixture of theſe with the neceſſary quantity of lime water, ought to be made quickly, and the cement or mortar thus prepared ought to be uſed immediately, leſt the lime ſhould imbibe carbonic acid from the air, before it has been placed where it ought to cryſtallize and cement the contiguous quieſcent parts. A greater quantity of lime than this, in which it compleatly intercedes the ſurfaces and fills the ſpaces of the ſand, is unneceſſary in mortar, and is injurious in incruſtations; becauſe more lime requires more water, and ſuch ſtucco ſhrinks and cracks in drying.

If lime for incruſtations be not perfectly and equally ſlaked, the unſlaked grains will cauſe bliſters in the work: therefore the lime for this uſe ought to be kept ſlaked for ſome

 days,

days, but guarded from the entry of carbonic acid gas. This is effected by the cruft which forms on the furface of water with which it ought to be covered. When an incruftation becomes dry and hard throughout, it will imbibe lime water in confiderable quantity, and being two or three times wetted with it, will become much harder and more durable.

Lime which contains Argil in confiderable quantity, as Darking lime and Barrow lime, have their peculiar ufes and modes of treatment.

MINUTES

OF THE

FIFTH MEETING,

ON

SATURDAY, February 22, 1794.

PROPOSITION.

" *Preſſure co-operating with attractive Forces*
" *towards the Approximation or Aggregation*
" *of the Parts of Bodies, tends to the Extri-*
" *cation of a Part of the engaged Caloric.*

" REMARKS ON THE OBJECTIONS TO THESE
" NOTIONS OF COMBINED CALORIC."

" THE preſent plan, ſaid the Experimen-
" ter, requires that experiments be made in
" the order which the circumſtances of the
" Elaboratory will permit, and that general
" principles be illuſtrated if not eſtabliſhed,
" before any ſtrict calculations be attempted,

" A confiderable latitude in fpeech is ad-
" miffible under thefe circumftances; and
" the phenomena ought to be noticed as they
" arife, whether they relate to the announced
" propofition or not; for thus one experi-
" ment may ferve many purpofes."

The bufinefs of this evening requiring the affiftance of all the experimenters; Mr. JOHNSON took the part of fhewing and explaining the proceffes for the preparation of fulphuric Ether for experimental ufe.

He gave the neceffary cautions to prevent danger, and to obtain the ether in the greateft quantity and in the pureft ftate; and noticed the phenomena which relate to the nature of Caloric, and to the propofition on the tablet; and referred to the numerical book of the laboratory, in which under the article Ether fulphuric, the improvements now made were briefly defcribed, as follows.

" Equal parts of alkohol and ftrongeft
" fulphuric acid, are to be mixed in a retort
" by adding the latter to the former, in
" fmall portions at diftant intervals, fo that
" the heat of the mixture fhall not exceed
" 120, until the laft portion of the acid has
" been introduced.

" The

" The retort is then to be placed in a
" ſand bath previouſly heated, ſo that the
" diſtillation may ſoon commence at the
" boiling point. As ſoon as poſſible after
" the retort has been placed, a tubulated
" receiver is to be luted to it, in the man-
" ner deſcribed by LAVOISIER, and the
" bottle which is to receive the diſtilled li-
" quor is to be well fitted to the tube of
" the recipient. When the weight of the
" ethereal liquor firſt diſtilled is to that of
" the alkohol as 14 to 32; or when the
" ſmalleſt quantity of an heavy liquor ap-
" pears under the ethereal, the bottle is to
" be immediately removed and cloſed with
" a glaſs ſtopple. Another bottle is to be
" fitted to the recipient to receive the ſub-
" ſequent products, which conſiſt of a yel-
" lowiſh ſulphureous ethereal fluid, floating
" on an acid watery liquor, both making
" 1-8th of the weight of the alkohol.

" If the bottle be not removed about this
" period, the junctures will be forced by
" the ſulphureous gas, and the black ſul-
" phureous liquor in the retort will ſuddenly
" expand and froth, and paſs into the reci-
" pient.

"To

" To ſeparate the ethereal from the watery
" and acid part of the laſt product, without
" waſte, the bottle looſely ſtopped is to be
" inverted; and if the preſſure of the gas
" within ſhould not expel all the watery
" part, a warm cloth applied about the bottle
" will do it. The liquor thus ſeparated
" from the watery portion, is the oil of
" wine of former Chemiſts, and is to the
" alkohol in weight as 1 to 16. It conſiſts
" of ether and ſulphureous acid, and not
" of oil as has been imagined.

" It is to be poured on eight times its
" weight of aqua kali puri, and the bottle
" being ſtopped, is to be agitated, but only
" a little at a time, in order that the ſul-
" phureous acid may be withdrawn from the
" ether, with the ſmalleſt augmentation of
" temperature; for quicker mixture cauſes
" heat, which is attended with waſte of
" ether, or the danger of burſting the veſſel.
" When the ether has ſeparated from the
" ſaline liquor, the latter is to be excluded in
" the manner above mentioned, and the
" ethereal part is to be mixed with that
" which was firſt diſtilled, together with
" as much aqua kali puri as will entirely
" ſup-

" ſupprefs the ſulphureous ſmell. The
" neceſſary quantity of aqua kali puri for
" theſe purpoſes, is about half the weight
" of the alkohol.

" It is now to be obſerved that frequent
" agitation and perfect mixture in a veſſel
" well ſtopped, are as neceſſary as the due
" quantity of the alkali, towards withdraw-
" ing the ſulphureous acid from the ether.

" When the ſmell is purely ethereal, and
" the taſte diſcovers a ſlight exceſs of alka-
" li, the liquor without boiling is to be very
" ſlowly diſtilled in veſſels well luted. The
" product in ether, will be to the alkohol,
" in weight, as 11 to 32; and the oily film
" which remains floating on the ſaline li-
" quor in the retort will not amount to more
" than about 15 grains for every 32 ounces
" of the ſpirit employed. Even this quan-
" tity depends in a great meaſure on the
" ſulphureous acid ſtill retained. Theſe
" things deſerve attention, in the preparation
" and adminiſtration of the modern oil of
" wine.

" Even this ether may ſtill be improved by
" agitating it well with 1-20th of its weight
" of aqua kali puri, and diſtilling it in a heat
" not

"not exceeding 100°. The portion firſt drawn
"off and amounting to 3-4ths of it, is to be
"ſaved apart for experimental uſe. What fol-
"lows, until the liquor in the retort ſhews
"only a thin film of ether, is to be reſerved
"for inferior purpoſes, although it be purer
"than ordinary ether made with ſpirit of wine.

"It is to be obſerved in this proceſs, that the
"changes take place, not at the loweſt tempe-
"ratures at which the alkohol and acid may be
"made to mix, but at the higher temperature
"neceſſary for boiling; and this may be enu-
"merated amongſt the experiments which
"ſhew the agency of Caloric in combinations
"and decompoſitions; the reſidue of the de-
"ſcribed products from alkohol and ſulphuric
"acid, conſiſting of ſulphuric and ſulphureous
"acid, the ſaline impurities of the ſulphuric
"acid, and a part the carbo which belonged
"to the ſpirit."

EXPERIMENT II.

After a few experimental illuſtrations of atmoſpheric preſſure, and of the elaſticity of air, and of the uſe of inſtruments by which theſe are meaſured; an experiment ſimi-

ſimilar to that deſcribed at the 57th page of Mr. KERR's edition of LAVOISIER's Elements of Chemiſtry, was exhibited.

When the receiver of the air pump had been exhauſted of air, and the mercury in the included Barometer had ſunk to the common level; the double piece of bladder, which was faſtened on the mouth of an ounce meaſure cylindrical glaſs veſſel perfectly filled with ſulphuric ether, was pierced and cut aſunder. The ether immediatedly began to boil and to be changed into an inviſible fluid; and the boiling continued until the receiver was filled with the fluid; the elaſticity of which was ſufficient to preſs up and ſuſtain a column of mercury of ten inches in height, at the temperature of 45 degrees.

The remaining ether being now compreſſed by the ethereal gas, with a force equal to one-third of the weight of the atmoſphere, no longer boiled or exhaled. "The forces "therefore with which the molecules of "ether attract Caloric around them, to form "repellent charges, are greater than thoſe "of their attractions to each other, at this "diſtance of them and in this temperature, "by the whole weight of a ten inch co-

"lumn

" lumn of mercury ; and ſo much preſſion
" muſt co-operate with the attraction of ag-
" gregation, before the ethereal molecules
" can be approximated ſufficiently to form
" ether at the temperature of 45 degrees.

" Former experiments have ſhewn that
" the Chemical principles of ether ſeverally
" combine with Caloric, and retain it, in their
" gaſſeous form, under the greateſt known
" preſſures, and in the loweſt known tem-
" peratures. They have alſo ſhewn that
" theſe principles in combining exclude a
" great part of the charges of Caloric which
" they held in their ſeparate ſtate. This is
" moſt ſtrongly exemplified in the formation
" of carbonic acid gas and water.

" By a general law, molecules conſiſting
" of combined particles, are incapable of re-
" taining all the Caloric of the ſeparate par-
" ticles; and it is ſcarcely to be doubted
" that the Caloric excluded, during the
" combination, is that chiefly which be-
" longed to the ſurfaces by which the par-
" ticles combine ; ſince the molecules ſtill
" engage charges of Caloric around them.
" In ether, theſe charges together with the
" Caloric of temperature, are ſufficient for

" its

" its expanſion into the ſtate of gas, in the
" circumſtances related, but not under at-
" moſpheric preſſure.

" The expanſion of the ether, and the
" permanent elaſticity of its gas which ſup-
" ports the column of mercury, ſhew that
" the molecules are not merely diffuſed in
" Caloric of temperature, but are carried
" away from each other by atmoſpheres of
" Caloric attached to them ; and the follow-
" ing experiment will ſhew that the re-
" ceding molecules can engage further quan-
" tities of Caloric, as the ſpaces between them
" are encreaſed during the further expanſion
" of the ethereal gas."

EXPERIMENT III.

An eight ounce glaſs tumbler, containing two ounces of ſulphuric ether, was placed on the plate of a powerful air pump. In this tumbler a thin bottomed bottle containing half an ounce of water, ſtood upright to the height of the tumbler ; and the mouth of this bottle was covered with a piece of moiſt bladder, to prevent the ſpray of the ether

ether from falling into it. Cloſe by this bottle ſtood a ſmall thermometer in the ether.

Over theſe a receiver which had a ſmall aperture at the top, was placed; and over all, a common receiver cloſed at top was fixed on the plate, in order to avert the preſſure of the air from the internal veſſels, during the action of the pump.

As faſt as the included air was pumped away, the ether boiled, and the ethereal gas expanded. Filling the interior receiver, it paſſed through its aperture at the top, and then between it and the external receiver, from which it was pumped out.

The temperature of the air of the laboratory being as high as 70° at this time, tended ſtrongly to defeat the purpoſes of this experiment; and therefore things were thus contrived, in order that the gas of the compartment between the two receivers, ſhould engage the Caloric of the external air, and be pumped away with it, inſtead of being permitted to penetrate to the internal veſſels.

Counting from the moment when the ether began to boil, the mercury in the thermometer ſunk at every ſtroke of the pump; and it continued to ſink, the water in the

mean time freezing ſucceſſively until the whole of it became ſolid, and the temperature in the tumbler was 17 degrees below the freezing point of Farenheit.

It was affirmed by the Experimenter, on the veracity of gentlemen who aſſiſted in the experiment and could better ſee the ſcale of a ſmall thermometer, that in froſty weather, and with an external receiver covered with woollen cloth, the temperature may thus be reduced to forty degrees below the freezing point.

Theſe experiments tend with many others to ſhew that preſſure contributes eminently to the denſity and aggregation of divers bodies, and to leſſen and limit their quantities of Caloric ; and that particles or molecules already combined with determinate quantities of this ſubtile matter, never fail to compel more of it into a ſtate analogous to that of weak combination, when the diſtances of the particles are encreaſed to admit the ſuperadded Caloric.

The additional Caloric which ether fixes and combines during the expanſion, is ſufficient to raiſe the thermometer from the 15th to the 70th degree, for this quantity no

longer ſubſiſts in it as Caloric of temperature, from which it is withdrawn.

EXPERIMENTS IV. V. and VI.

Alkohol tried in the ſame way afforded the like phenomena and inferences; except that the elaſticity of the expanded alkohol was only 1-10th of that of ether, and the refrigeration was proportionally ſmaller. When water was placed in the ſame circumſtances, the elaſticity of its vapour was only one-fifth of that of alkohol, and the refrigeration was conſequently much leſs.

EXPERIMENTS VII. VIII. IX. and X.

Theſe experiments having been formerly made by the Experimenter, a temperature of the ſubjects veſſels and ambient air, amounting to 96° or a little more, the heights of the mercurial columns ſuſtained by the expanded gaſſes or vapours were conſiderably encreaſed if not doubled; and it was inferred that as the denſity and preſſion of the Caloric of

of temperature encreafes, the molecules or particles of vapours and gaffes engage greater charges of Caloric around them.

"Thus the preffion of Caloric tends to "counteract that of the atmofphere, and "may be made to balance or exceed it."

EXPERIMENTS XI. XII. XIII. XIV.

Brifk ale and cyder treated in the fame way, fwelled and frothed exceedingly during the emiffion of their carbonic acid gas, fuftained higher mercurial columns than any of the former, and generated cold. So did ftrong muriac acid by the expanfion of the acid gas, and faturated aqua Ammoniæ puræ by the expanfion of the ammoniacal gas. Divers other inftances of the effects of preffure and of the contrary effects of expanfion, were enumerated; and divers practical applications of this knowledge were made.

In the recital of thefe laft, it was obferved that Ethers, volatile acids, ammoniacal liquors, and all fubjects eminently volatile by their tendency to Caloric and the gaffeous ftate, ought to be diftilled under the full

preſſure of the air, aided by cloſe lutings or other means of reſiſtance to their expanſion: and in the diſtillation of ſpirits and eſſential oils which are injured by unneceſſary augmentations of temperature, the ſtill ought to be ſhallower, and the beak of the ſtill head and cavity of the worm wider than is uſual; in order that the diſtillation may be carried on with leſs preſſure, and at a lower temperature.

EXPERIMENTS XV. XVI. XVII.

In the manner of LAVOISIER, page 60 of KERR's edition, a bottle was filled with an ounce of ſulphuric Ether, and in its mouth a glaſs tube bent like the letter S was inſerted. The bottle and tube were plunged into water heated to 104+ degrees. When the Ether had acquired this temperature, it boiled, and with the Caloric formed an aëriform fluid, which when received in bottles which ſtood in the water and had the ſame temperature, remained elaſtic whilſt this temperature ſubſiſted, but at lower temperatures gradually condenſed into Ether;

as

as it was all the while expoſed to the preſſure of the air.

As Ether may be made to boil at or below Zero, by averting the preſſure of the atmoſphere firſt, and then withdrawing the Ethereal gas, which next preſſes on it; the compreſſing power of the atmoſphere is equal to the expanſive power of about 103 or 104 degrees of Caloric. And the ordinary boiling point of Ether is that at which the quantity and preſſion of Caloric of temperature, is ſufficient to overpower the compreſſing forces and thoſe of the aggregating attractions.

By ſimilar experiments with alkohol and with water, in the manner of LAVOISIER, the heats neceſſary for their boiling and for maintaining the volume and elaſticity of their vapours, under atmoſpheric preſſure, were ſhewn: And as the vapours condenſed when each was cooled a little below the boiling point, although the heat was ſtill much more than would be ſufficient to maintain the vaporous ſtate in veſſels averting the preſſure of the air, the inferences formerly expreſſed were applied here.

EXPERIMENT XVIII.

The effect of atmofpheric preffure on faturated faline folutions was exemplified in the following experiment.

A narrow necked glafs mattrafs capable of holding three wine gallons of water was ground flat and fmooth at the mouth, to prevent the edges from cutting the flip of bladder which was to be tied on it. The mattrafs was fixed in a veffel filled with water faturated with fea falt. One hundred and forty four ounces troy of a vitriolated Natron perfectly neutral or having flight excefs of Natron were diffolved in a feparate veffel in 96 ounces of water; and this folution was filtrated into the mattrafs. Before the whole had paffed through the filter, the faline liquor in which the mattrafs ftood, was made to boil, and was kept at this temperature to the end, in order that the fpace above the folution of vitriolated Natron in the mattrafs, fhould be fupplied abundantly with vapour to expel the air entirely. A flip of wet bladder was now quickly tied on the neck of the mat-

mattrafs; and when it was removed from the hot brine, another flip was tied on, the more effectually to fuftain the preffure of the air.

When the whole was cooled, the folution occupied about two-thirds of the capacity of the mattrafs; the remainder was void of air or nearly fo; and the bladder was preffed inwards by the incumbent air. If the fpace above the faline liquor be fmaller, greater care is neceffary in expelling the air by evaporation, and in tying on the bladder.

Two equal mattraffes charged and ftopped in this way, ftood for three days at temperatures fluctuating between 40 and 50 degrees, and were often in this time agitated without yielding any cryftals.

The temperature of thefe folutions and of the Laboratory being now at fixty, the cover of one of the mattraffes was pierced and cut open quickly with a knife; and inftantly as the preffure was communicated to the liquor, a few fmall concentric fpicular cryftals were formed, which fhot rapidly through the liquor, until the whole became confiftent, and almoft folid. The Caloric extricated in the mean time raifed the temperature from 60 to 90 degrees in every part of the faline

maſs, which could now ſupport a mercurial thermometer, wherever it was placed.

The cover of the ſecond mattraſs, was then pierced, and with the like event. Thus the quantity of Caloric extricated and expelled by atmoſpheric preſſure, co-operating with the attraction of the diſtant molecules of ſalt, was thirty degrees, in the ſalt and water.

" An experiment of this kind was made
" in froſty weather laſt year; when the
" temperature of the ſaline liquor and of the
" laboratory was 40 degrees, a gentleman
" who applied the thermometer, ſaid that it
" ſtood at ninety degrees in the cryſtallized
" maſs; and if there was no error in the
" obſervation, the extricated Caloric encrea-
" ſed the temperature of the water and ſalt
" by 50°."

Doctor LATHAM queſtioned, whether the air might not have entered the ſolution and produced theſe effects, independently of the preſſure. The Experimenter therefore reſolved to try the preſſure of mercury inſtead of air, as ſoon as the neceſſary inſtruments ſhould be provided. The firſt and moſt ſimple of theſe ſhould be a very wide and long barometer, heated to 150 degrees, and ad-

admitting a few ounces of the hot ſolution to be paſſed through the heated mercury and to ſtand above it.

" If the ſolution when cooled to 40 de-
" grees without cryſtallizing, ſhould preſent
" the foregoing phenomena, in conſequence
" of a ſlow inclination of the tube, and the
" ſmalleſt poſſible agitation of the liquor,
" Dr. LATHAM's queſtion will be anſwered."

It was obſerved that divers ſalts treated in the ſame way, with their due quantities of water, preſent the like phenomena.

" Water alſo exhauſted of air, and placed
" above the mercury in a large barometer,
" and cooled two or three degrees below the
" freezing point, without ſhewing any ſign
" of congelation, ſoon freezes, after the preſ-
" ſure of the air has been reſtored by in-
" clining the barometer.

" Experiments of this kind ſhew the de-
" ſcribed effect of preſſure co-operating with
" the attractions of the diſtant parts of the
" ſalts. They ſhew that by the coaleſcence
" of theſe parts, a portion of the Caloric
" which interceded them is forced away
" from its ſtate of engagement or combina-
" tion into that of Caloric of temperature.

" The

" The experiments in which cold is pro-
" ducible by ſolution do not properly be-
" long to this place; but in an introduction
" of this kind it is not improper to announce
" in general terms, that in all inſtances of
" the expanſion of bodies, or of ſolutions, in
" which the parts attractive of Caloric are
" made to recede from each other; the conſe-
" quent and certain production of cold ſhews
" that bodies which attract Caloric contain
" it in two ſtates; a part being more or leſs
" intimately combined, the remainder in
" the ſtate of Caloric of temperature.

" To conclude theſe obſervations which
" are merely introductory, concerning Ca-
" loric, the following remarks are to be
" made.

" As the dimenſions of bodies decreaſe
" with their Caloric of temperature, which
" cannot be entirely withdrawn from them
" in any practicable refrigeration; it is not
" at all probable that the natural parts which
" conſtitute an aggregate, are ever in a ſtate
" of abſolute contact. On the contrary the
" optical and divers other phenomena ſhew
" that the ſpaces in bodies are much greater
" than the ſolid matter of them, and that

" a cer-

" a certain proximity of parts, at which the
" aggregating and expanding powers are
" balanced, is competent to the ſtate of com-
" bination and aggregation.

" Therefore abſolute contact is neither
" implied nor neceſſary in the Chemical
" combinations of the groſſer parts of bodies
" or in the combinations of Caloric. The
" term combination expreſſes a connexion or
" condition maintained by attraction, and
" capable of altering the agency and ordi-
" nary characters of the things connected or
" combined. *Such are the combinations of*
" *Caloric.*

" It is ſufficient for our preſent purpoſe
" thus to announce theſe characters of Calo-
" ric, and to impreſs them on our minds by
" the eaſieſt experiments. It is after a due
" conſideration of the means of meaſuring
" temperatures and quantities of Caloric,
" that the moſt deciſive proofs of the agen-
" cy and ſtate of this matter in bodies,
" ought to be produced."

MINUTES

OF THE

SIXTH MEETING,

ON

SATURDAY, March 1, 1794.

PROPOSITION.

" *Analyfis and Synthefis of Atmofpheric Air.*"

AFTER a general defcription of the natural and artificial proceffes, in which divers fubftances are, in continued fucceffion, refolved into the ftate of gaffes, and mixed with the air; the Experimenter adverted to the inftruments and powers by which moft of thefe gaffes and vapours are fpeedily withdrawn from it, and the common mafs of circulating air is made to confift almoft entirely of two elaftic fluids, namely the Azotic, and

and Oxygenous, which muſt meet peculiar ſubjects and circumſtances, before they return to the common terraqueous maſs, or combine with each other, to the excluſion of Caloric.

" Avoiding local impregnations and con-
" taminations of air, we find the proportion of
" the azotic to the oxygenous gas, to differ
" very little; whilſt the aqueous gas diffu-
" ſed in it, varies with the temperature and
" other circumſtances.

" It is not to be admitted that the aqueous
" matter is held in air in a ſtate of ſolution
" or combination; for divers experiments
" ſhew that its gaſſeous ſtate depends on its
" proper Caloric, by which its parts are kept
" diſtinct from thoſe of air."

To explain this ſubject, it was ſhewn that the lighteſt ſubſtance covering the mouth of a bottle filled with muriatic acid, or with aqua Ammoniæ puræ, was ſufficient to prevent the exhalation of either; becauſe this cover ſuſtained the preſſure of the air, and communicated the whole of it to the liquors. But when the covers were removed, each bottle exhaled gas copiouſly, and a thick white ſmoke appeared where the gaſſes met and formed a ſalt.

" Ether

" Ether in like manner is detained by the " lighteſt covering, but eſcapes rapidly from " uncovered veſſels.

" Many experiments of this kind might " be made to ſhew that liquors openly " expoſed to the air, if they be diſpoſed to " aſſume the vaporous or gaſſeous ſtate, will " eſcape through its interſtices, inſtead of " ſuſtaining its full preſſure.

" In the ordinary temperatures and preſ- " ſures, water maintains its form, ſo long as " any impervious ſubſtance ſtands between it " and the air and imparts the atmoſpheric " preſſure. But water, whoſe ſurface is free- " ly expoſed to air which is in motion, and " is pervious to any gas, is as much at liber- " ty to form aqueous gas, as it is when a " conſiderable part of the atmoſpheric preſ- " ſure is averted.

" Thus aqueous molecules charged with " Caloric are continually diffuſed in the air, " and in a ſtate from which the atmoſpheric " preſſure cannot compel them to form wa- " ter: becauſe this preſſure is ſuſtained by the " two permanently elaſtic fluids in which the " diſtant aqueous molecules are poiſed.

" Theſe particulars and a ſmall quantity of

"Carbonic acid gas wafted in the air, are to "be obſerved in many experiments; but in "thoſe which follow we may chuſe air in "which theſe bear too ſmall a proportion, "to merit our preſent attention; and there-"fore we may conſider it as a mixture of "azotic and oxygen gaſſes which are ſepa-"rable from each other by various means, "a few of which are now to be ſhewn."

EXPERIMENT I.

Mercury was boiled for three weeks in a veſſel open to the air, in order to form it into the oxyd commonly called Hydrargyrus Calcinatus; and in the mean time the alphabetical and numerical books of the laboratory were referred to for the neceſſary inſtructions, a few of which are ſubjoined in conformity with a general order of the committee of publication.

The bottom of the glaſs veſſel containing the mercury ought to be perfectly flat in order that the ſmaller quantity of mercury may cover it entirely, the diameter being no leſs than ten inches, and the perpendicular tube

tube which is continued from the flat conical body having 1-7th of the diameter of the bottom, and the length of two feet. This length prevents the eſcape of mercurial vapour, and this diameter admits the neceſſary circulation of air. Over the mouth of the tube a ſmall funnel ought to be ſuſpended to prevent the entry of duſt from the air. The bottom of the veſſel ought to ſtand parallel with the horizontal plate of a ſand bath, and an inch from it, on a bed of coarſe ſand, which ought to be heaped around the veſſel, and to ſlope upon its conical part, ſo as to cover it near the circumference, to the height of two inches or more; but ought not to cover the narrow part which joins with the upright tube, for there the progreſs of the evaporation ought to be ſeen.

A boiling heat is to be continued whilſt the mercurial vapour is found to riſe and condenſe in the tube and trickle down its ſides, but no greater heat is to be uſed. When theſe appearances ceaſe the tube retains a film of mercury which ſilvers it and remains undiſturbed. The oxyd now formed is not all perfectly equal, and cannot be taken out

of

of the veſſel without ſome agitation which throws into it mercurial globules from the film. It is therefore to be placed in a ſhallow earthen diſh in a muffle, there to be heated gradually and equally at the ſurface as well as the bottom, until it becomes uniform in colour and pure, in a heat not exceeding 600°. The product is called oxyd of mercury by calcination, to diſtinguiſh it from that which is prepared by the nitric acid, more conveniently and equally fit for experimental uſe.

The ſmaller the waſte of mercury is in this operation the nearer will be the weight of the oxyd to that of the metal as 8 to 7. But in general the former is to the latter as 7.8 to 7 after ſubtracting the uncalcined mercury.

EXPERIMENT II.

The inſtruments deſcribed by LAVOISIER for oxydating mercury in a determinate quantity of atmoſpheric air, and aſcertaining the abſolute quantities of its azotic and oxygenous principles, were found inconvenient, and incompetent to theſe purpoſes.

Therefore a ſhallow half pint retort having its bottom flatted and its neck drawn out to the length of 15 inches, was provided.

A glaſs funnel capable of holding two wine quarts was bent at the narrow part, ſo that the ſtem, which was nine inches in length, formed an angle of 80° with the axis of the conical part.

The tube of the funnel was ground into that of the retort with fine emery, and the capacity of the veſſels thus joined, was aſcertained in cubic inches, by the weight of water which they held.

The veſſels being well dried, the flatted retort was charged with four ounces of the pureſt quickſilver, and the funnel being joined as before, they were faſtened together by means of a wax cement, ſuch as is uſed by the makers of philoſophical inſtruments.

The included air had no communication with the wax; becauſe the tubes were fitted by grinding, and the wax was uſed only for the ſecurity of the juncture and of the poſition of the veſſels.

When the retort was placed on the ſand, where it was to be heated, its neck, inſtead of being inclined as is uſual in diſtillations,

was elevated ſo far as to cauſe the mercury which might riſe into it, to trickle back into the body.

In order to condenſe the included air, and to prevent the eſcape of any part of it during the dilation of the air and mercury in the retort, a weight of ten pounds was placed on the curvature of the funnel, ſo as to depreſs its mouth in a deep trough of mercury.

The whole might be well repreſented by luting two flat bottomed retorts together, ſo that their bottoms ſhould be almoſt in the ſame plane; and then cutting off the bottom of that whoſe neck enters the other.

Theſe things being prepared, the time choſen for including the air in the veſſels was when the barometer ſtood at 29.84+ and the temperature of the laboratory was lowered to 54.5°.

The charge of mercury was boiled inceſſantly for fourteen days: during which time the mercurial vapour which roſe into the neck, to the length of three or four inches, trickled back into the charge as faſt as it was condenſed.

If the veſſels had been immoveably fixed, this experiment could not have anſwered

better than that of Mr. LAVOISIER, except by the greater compreſſion of the included air: for when the oxygen of the air in the retort which muſt be ſmall, has been expended, the reſiduary azotic gas intercedes the mercurial vapour and the air in the funnel, through the whole length of the joined necks, and renders the total expenditure of the oxygen not only tedious but impracticable.

But as the funnel ſtood buoyant in the mercurial trough, every depreſſion and elevation of it had the effect of pumping the air to and from the retort; and it was accordingly moved in this manner often every day, during the 14 days, although the diminution of volume ſeemed to ceaſe on the ſixth day.

When the mercury had boiled for a few hours, a ſlight film obſcured its metallic luſtre. This film encreaſed gradually until the mercury had the appearance of tarniſhed lead; and in leſs than 48 hours after this appearance, ſmall cryſtals of dark brown oxyd were formed on the ſurface.

Theſe encreaſed gradually in ſize until they covered the whole of the mercury and at laſt formed a thick friable cruſt upon it.

When

When the veſſels were cooled, they were ſuffered to remain in this poſition until the barometer which was riſing had arrived at the height above mentioned, and the laboratory was cooled to 54.5°. Then water was introduced into the funnel to depreſs the mercury; and the veſſels being firmly faſtened when the water at the inſide and outſide of the funnel was perfectly level, the funnel was marked with a diamond pencil at this level in eight different places; ſo that by corking the neck of the funnel and filling it with water to the diamond mark, which directed the proper poſition of it, the additional quantity of water which it could hold, might be a correct meaſure of the loſs of bulk from the air firſt included, and conſequently of the oxygen gas expended in the oxyd.

Previous to this menſuration, four cubic inches of the gas, were taken out with due attention to temperature and preſſure, and were delivered into a larger cylindrical veſſel filled with ſulphuret of lime and inverted in it, to which the gas was fully expoſed for two days, the ſurface of the ſulphureous liquor being in the mean time often agitated. The gas being then returned into the mea-

ſure, was found to be very little diminiſhed in bulk, and not more than might juſtly be imputed to the unavoidable waſte in paſſing through a tenacious liquor into the large cylinder and afterwards into the meaſure.

A lighted taper was then quickly dipped in this azotic gas, and was inſtantly extinguiſhed. What remained in the retort and funnel might therefore be conſidered as mere azot, the bulk of which was to be aſcertained, by ſubtracting the meaſured bulk of the oxygen gas from that of the air at firſt employed.

The greater part of the azotic gas being withdrawn from the funnel was reſerved for uſe.

The retort being cut circularly near the helm with a diamond, the mercury and oxyd were poured into a paper funnel which ſuffered the former to paſs off in a very ſlender ſtream, and detained the latter. The oxyd which adhered to the ſides of the retort, to the height of two inches or more above the ſurface of the mercury, and there formed a pellicle and ſtreaks of ſmall cryſtals of oxyd, was carefully ſcraped off with a ſharp

knife,

knife, and added to that in the paper funnel. This being inverted and opened on ſmooth paper, the mercurial globules which it entangled were removed with due care, but ſtill there were minute globules and a mercurial film which could not thus be ſeparated. Therefore the oxyd was ſpread on a flat piece of porcelain, and placed in a muffle well heated to 600°, where the mercury evaporated in two or three minutes.

If the oxyd had not been thus ſuddenly heated, ſome of the mercurial film might have been oxydated in the maſs by the air; but this could not happen to mercury paſſing off in vapour, ſo as to encreaſe the oxyd in any ſenſible degree, in ſo ſhort a time.

The bulk of the azotic gas and oxygen gas employed, being aſcertained in the manner above mentioned, and the weight of each being calculated according to the method of Lavoisier hereafter to be explained, the proportion of the azotic gas to the oxygen gas appeared to be nearly as 73 to 27 in weight; which is the proportion aſcertained by more accurate experiments than that in which he attempted to transfer the oxygen of air to

mercury, under circumſtances highly diſadvantageous.

It is ſurpriſing that this excellent Philoſopher ſhould not have adverted to the true cauſes of the imperfection of his experiment, in which the long and narrow neck of his retort was an impediment to the neceſſary circulation and mixture of the air of the reſervoir with that which had loſt its oxygen gas in the retort; and in which the preſſure of the atmoſphere was leſſened at firſt, and daily diminiſhed afterwards; nothing being done in the mean time to mix the cold part of the air which was leaſt altered, with the hotter in the retort which had delivered its oxygen to the mercury.

The obſtacles on which he reckons are "The mutual adheſion of the two conſtitu-"ent parts of the atmoſphere for each other, "and the elective attraction which unites the "baſe of vital air with Caloric; in conſe-"quence of theſe, when the calcination "ends, or is at leaſt carried as far as is poſ-"ſible in a determinate quantity of atmoſ-"pheric air, there ſtill remains a portion of "reſpirable air united to the mephitis which "the mercury cannot ſeparate."

This

This reaſoning is by no means admiſſible. The particles of azot and oxygen charged ſeverally with Caloric, and repelling by virtue of theſe charges, can have no adheſion to prevent the oxygen from uniting with the mercury; and his own experiment as well as this of the ſociety, ſhews that the Caloric of oxygen gas cannot prevent its union, or to ſpeak more ſtrictly, the union of its baſe with mercury at the temperature of 600. The agency of high temperatures in ſuch unions, is to be conſidered in its proper place.

EXPERIMENT III.

As there was no reaſon to doubt concerning the experiment of LAVOISIER page 84, in which he obtained empyreal air or oxygen gas, by heating the oxyd thus prepared in cloſe veſſels, it was deemed unneceſſary to encounter the inconveniences which muſt attend ſuch an operation on the ſmall quantity produced in the preſent proceſs; at a time when the experiment in the next furnace yielded oxygen gas abundantly, from eight ounces of oxyd of mercury by calcination in a veſſel

open

open to the air; with this advantage, that the atmoſpheric air of the ſlender neck of the retort and of the interſtices of the charge had been compleatly expelled, before the pure oxygen gas was ſaved for uſe.

Such properties of it as demanded immediate attention were ſhewn. A taper burned in a pint of it with ſurpriſing ſplendour and rapidity, in compariſon with the ſlow and ordinary combuſtion in air; and a bit of reddened charcoal inſtead of burning faintly and ſoon extinguiſhing as it would in common air, ſparkled, crackled, glowed with great brilliancy, and was quickly burned out.

EXPERIMENT IV.

The azotic gas above mentioned, whoſe properties are the reverſe of theſe in regard to combuſtion was mixed in different proportions in ſeparate veſſels with this oxygen gas. In a mixture made in the proportion of atmoſpheric air above deſcribed, theſe combuſtions took place as they do in open air. In ſmaller proportions of the oxygen gas the combuſtions were more languid; and as the oxygen

gas

gas was made to predominate, the mixture had the ſtronger effect.

" In general the oxygen gas is the only " part of air which acts in the combuſtion of " bodies, and the azotic gas is perfectly paſ- " ſive, or an impediment, by diluting the " former, and weakening its operation."

The combination of Caloric in the oxygen gas and combuſtible bodies, and the extrication of Caloric and Light during theſe combuſtions were duly noticed; and it was affirmed on grounds of analogy, that during the oxydation of mercury, a ſlow combuſtion took place, and the combined Caloric was detached in great quantity from the oxgen gas, if not from the mercury; but not with velocity ſufficient to conſtitute light, nor in ſuch quantity, at ſhort intervals, as to be diſcoverable in a maſs whoſe heat of 600° was confounded with it.

EXPERIMENT V.

In obtaining the oxygen gas from eight ounces of oxyd of mercury prepared by calcination, the following particulars were obſerved.

" Every

" Every maſs which has interſtices acceſ-
" ſible to air, acts on it by capillary attraction
" and draws into theſe interſtices not only
" as much of the air as equals them in bulk,
" but an additional quantity condenſed with
" the former by virtue of the capillary at-
" traction. And therefore a retort charged
" with oxyd of mercury contains not only
" the air of the neck and helm, but may
" contain twice as much as would, in the
" ordinary ſtate, fill it.

" Therefore the retort ought to be as
" ſmall as the charge duly packed will per-
" mit, and the neck as ſlender near the
" helm as it can be made. The fire being
" gradually raiſed, a hot bar of iron ought
" to be approached to the neck in order to
" dilate and expel the air from it; and the
" oxygen gas which follows when the
" coating of the retort begins to redden,
" ought not to be conſidered as pure, until
" ten meaſures each equal to the retort in ca-
" pacity have been ſucceſſively filled. The
" middle and laſt portions of the whole oxy-
" gen gas, are ſtill to be held as the pureſt.
" The ſize of the water trough, and the
" water employed to fill the bottles ſucceſ-

" ſively,

" ſively, before they are inverted on the fun-
" nelled ſhelf, ought to be as ſmall in quan-
" tity as is poſſible; that which ſerves for
" the firſt and ſecond pint of gas, being ſuf-
" ficient for all that follow, if it be ſaved.
" With theſe precautions water which has
" been previouſly boiled, will imbibe leſs of
" the oxygen gas, and furniſh leſs of any
" other.

" The beſt time for this experiment is
" when the temperature of the place may
" eaſily be kept at 54.5°.

" The bottles ought to be ſo far filled,
" that in putting in their glaſs ſtopples, no
" gas ſhall be excluded, nor any conſidera-
" ble quantity of water retained. Being
" then placed with their necks invert-
" ed in water, they will preſerve the
" oxygen gas unaltered for many months.
" But if water ſhould have acceſs to them,
" the gas will ſoon be impure; for the oxy-
" genous gas which the water imbibes ſlow-
" ly, is gradually delivered into the open
" air, eſpecially when light acts on them,
" and the place of the oxygen gas is ſupplied
" by azotic gas from the water.

" The doubts concerning the compoſition
" of

" of water from Hydrogen gas and oxygen " gas, have arifen chiefly from inattention " to thefe particulars.

" To prevent any lofs of gas during the " removal of a filled bottle, nothing more is " neceffary than that the cavity of the fun- " nelled fhelf fhould be large enough to hold " two ounce meafures of gas, and that the " affiftant fhould ftop the narrow aperture " with his finger introduced through the " water under the fhelf, until a frefh bot- " tle is placed over it.

" The narrow aperture of every fhelf of " this kind, ought to have a border rifing " a little above the common plane, in order " to deliver the gas freely into the bottle, " when it is inclined a little for the purpofe " of giving a free defcent and lateral paffage " to the water, between the bottle and the " fhelf.

" This method of menfuration is pre- " ferable to that by the gazometer of Lavoi- " sier, which by its complex mechanifm is " an imperfect meafure, and by the great " extent of metallic furface and the quantity " of water which it prefents to the gas, is " highly exceptionable."

As

As it was intended in this experiment to ascertain the quantity of oxygen in this oxyde, the first pint measures to the number of five were kept apart, and the middle measure of the remainder was also reserved. This last appeared to be pure; and the azotic gas of the others was separated from the oxygen gas by sulphuret of lime, and duly measured. The bulk of oxygen gas was taken at a medium of 54.5° of temperature and 29.85 of pressure, in the method of LAVOISIER; and its weight was computed by the specific gravity of 1.3562.

This compared with the weight of the mercury found in the water trough and in the neck of the retort and well dried, shewed that the oxyd consisted of seven parts of mercury combined with less than one of oxygen. But as there was no waste of mercury, whilst some loss of oxygen gas was unavoidable in consequence of its exposure to the water, the proportion of seven to one was admitted.

These experiments afforded both analytical and synthetical illustrations of the composition of atmospheric air. The oxygen gas being separated from the azotic, and moreover decomposed whilst its base combined

with

with the mercury; and the mixture of 73 parts of the refiduary azotic gas with 27 of the like oxygen gas being found to recompofe atmofpheric air.

Converfations now arofe concerning Mr. DEVAYNES's queftion, "Whether Caloric has weight." But as the Secretary could attend to thofe only which were addreffed to the chair, the minutes exprefs no more than that it was the prevalent opinion that by analogy it muft be a gravitating fubftance. For as it attracts divers kinds of matter, and fuch attractions fubfift generally at all experienced diftances, but with diminifhed energy at the greater diftances, it muft gravitate to the terraqueous mafs; although the direct proof may be difficult or impoffible by reafon of the fubtilty of its parts, and of the imperfection of inftruments for weighing.

Dr. LATHAM expreffed his opinion that Caloric gravitates: and fupported it by various arguments. He related an experiment with vitriolated Soda, which indicated the affirmative of this queftion.

Mr.

Mr. YOUNG objected to the competency of this experiment; and oppofed it upon general grounds.

The Experimenter thought that Caloric gravitates; and expreffed his intention of exhibiting Dr. LATHAM's experiment in a mode that would be free from the objections made by Mr. YOUNG.

Dr. POWEL, in confequence of a converfation on the fubject of carbonic acid gas, defired that the following queftion fhould be inferted in the minutes, for future confideration.

"Does carbonic acid gas deftroy animal "life by the exertion of any noxious power, "or by the exclufion of oxygenous gas from "the circulating blood?"

Some gentlemen objected to the term aqueous gas, thinking that the word gas ought to be appropriated to fluids permanently elaftic. But others thought it admiffible for the reafon affigned by LAVOISIER, and efpecially in the circumftances in which the vapour is not condenfible into water, by atmofpheric preffure.

MINUTES

OF THE

SEVENTH MEETING,

ON

SATURDAY, March 15, 1794.

"*Analyſis and Syntheſis of Atmoſpheric Air.*"

EXPERIMENT I.

AN inſtrument ſimilar to that of the ſecond experiment of the laſt meeting, was ſupported at the juncture, ſo that the retort which contained four ounces of ſtrong ſolution of ſulphuret of lime, might be agitated without inconvenience, and the funnel might alſo be moved in the mercury to pump the included air to and from the retort.

As the ſulphuret ſoon imbibed oxygen at the ſurface and formed a pellicle of calcareous ſalt, which ſtanding between the oxygen gas of the air and the ſulphuret, prevented any further

further abſorption; this pellicle was frequently broken by agitation, which alſo ſerved to ſpread the liquor over the ſides of the retort, and to preſent it with a more extenſive ſurface.

In the courſe of twelve hours the volume of the air was conſiderably diminiſhed, and for two days it continued to leſſen, but more ſlowly; the quantity of calcareous ſalt depoſited on the ſides of the retort and in the liquor encreaſing all the while. In the courſe of five days the whole of the oxygen gas or of its baſe, was depoſited in the contents of the retort, the azotic gas remaining unaltered.

This was proved by its bulk, which was aſcertained by marks on the funnel in the manner formerly deſcribed, and alſo by trials of its purity.

Had it been intended to meaſure the quantity of oxygen neceſſary towards the formation of a given quantity of ſulphur and lime, into ſulphuret or ſulphite of lime, a ſtop cock ought to have been inſerted in the funnel at its curvature, through which all the azotic gas of the funnel might be forced out, by depreſſing it in the mercury. But this azot was removed by raiſing the funnel

out

out of the mercury, and blowing in it, after its narrow neck had been ſtopped with a cork.

The cork being removed, the funnel now filled with freſh air, was placed in its former ſituation; and by a continuation of the proceſs above deſcribed, the ſucceſſive portions of air underwent the ſame changes, until the liquor which was quite yellow had depoſited the calcareous ſalt, of which water can diſſolve very little, and the water now freed of ſulphur and lime became colourleſs.

Thus the oxygen of any quantity of air may be ſucceſſively withdrawn from it.

In preparing ſulphuret of lime with one part of flowers of ſulphur, three of ſtone lime, and thirty-two or more of diſtilled water, the ſulphur is to be firſt ground with a little water and diffuſed in the remainder; and the lime broken into ſmall fragments is to be added. A glaſs mattraſs charged with theſe up to the narrow part, and ſtopped with a cork, is to be placed in hot ſand, and very often agitated during an hour's ſimmering, to prevent the adheſion of the ſulphurated maſs to the bottom. The liquor ſoon clears by cooling and ſubſiding, and undergoes no

change,

change, ſo long as the column of azotic gas in the long neck of the mattraſs is retained.

EXPERIMENTS II. III.

Sulphuret of Pot-aſh and Soda applied to air in the ſame way produced the like effect, towards the abſtraction of its oxygen gas; but in the uſe of theſe, the ſalts formed were more ſoluble and conſequently remained diſſolved in the water until the ſaline liquors were reduced by evaporation, ſo far as to depoſit cryſtals in cooling.

In making either of theſe ſulphurets, the cauſtic alkaline liquor weighing ſixteen ounces troy for each pint, ought to be boiled with a little more ſulphur than it can diſſolve, and with the precautions obſerved in the preparation of ſulphuret of lime.

EXPERIMENT IV.

Eight ounces of freſh and bright iron filings of the finer ſort, were mixed with three of flowers of ſulphur, and formed quickly into a paſte with water in a warm mortar. The

maſs was flatted to the thickneſs of an inch or more on a porcelain plate, and the cubic meaſure of theſe was taken. The plate was placed on a ſlender pedeſtal which ſtood in a trough of water ſo as to ſuſtain the plate at the height of ſeven inches above the water. A large round bottomed bell-glaſs meaſuring more than two gallons and graduated, was placed over the paſte, ſo as to include ſeven quarts of air around it, and about a quart of water below it. Thus the included air might be dilated conſiderably without eſcaping.

The glaſs was then preſſed by a weight to the bottom of the trough, and ſecured from riſing during the dilatation of the included air.

In conſequence of the compounded affinities of the ingredients thus applied to each other, and of their tendency to form martial vitriol, now named ſulphat of iron, the paſte was heated in a few minutes by the Caloric extricated during the union of the oxygen of the air with the ſulphur and iron, ſo as to dilate the included air conſiderably: and the aqueous vapour iſſuing in the mean time from the heated paſte, increaſed the dilatation, until the water was almoſt entirely expelled out of the bell-glaſs.

When

When the volume of theſe was conſiderably leſſened by cooling, as well as by the ſubduction of oxygen gas, the jar was often agitated during two days, without diſturbing the pedeſtal, in order that none of the oxygen gas, however diluted by azotic gas, might eſcape the action of the paſte.

The plate of paſte being withdrawn through the water, the azotic gas was meaſured, with due attention to the temperature and atmoſpheric preſſure; and its quantity was found to be, to that of the air employed, and to the oxygenous part depoſited, nearly in the proportions aſcertained in former experiments.

Previous to this menſuration of the azotic gas, it was fully expoſed to lime water for five or ſix hours, the latter being often agitated to promote the abſorption of any ſulphureous gas and Carbonic acid gas, with which the azotic gas thus procured, is apt to be impregnated.

In conſequence of the exhalation, the paſte became firm and bore the paſſage through the water without waſte. But being thus wetted, it preſently ſhewed by its ſmell and incaleſcence that the freſh air renewed the ac-

tion. It was therefore placed in the veſſel of air as before, where it acted in the manner already deſcribed; and afterward renewed its action a third time.

It was obſerved that a mixture of this kind when duly ſupplied with air and moiſture, forms martial vitriol: Sulphurated iron requiring oxygen only to produce this ſalt.

It was imputed to the velocity of this abſorption, and the quick expulſion of Caloric from the gas, that the temperature was ſo much augmented; and the ſlow progreſs of ſimilar decompoſitions of oxygen gas in the former experiments, was mentioned as the impediment to any ſenſible incaleſcence; the Caloric ſo ſlowly extricated being confounded with that of the temperature of the place.

Dr. PRIESTLY having obſerved many years ago that inflammable gas might be obtained from iron and ſulphur paſte expoſed to air in cloſe veſſels; the Experimenter mentioned the circumſtances in which the production of ſuch gas may be promoted or prevented: and conſidering it as a part of his duty to point out ſuch experiments as are dangerous, he related the following accident which happened in this place in the year 1775.

Having found a glaſs mattraſs which was unfit for ordinary uſes, on account of its extreme weight and thickneſs, he filled the body of it with about half a pint of paſte made with four parts of iron and one of ſulphur; and when the paſte was rammed down, he drained off the ſuperfluous water. Then filling the neck, which was twelve inches in length, with mercury, he inverted its mouth in a baſon of mercury. Knowing that ſuch paſte would ſwell conſiderably in air, he wiſhed to ſee what would happen to it when air was excluded; water being then conſidered as a ſimple and diſtinct element. He however took the precaution of placing the veſſel in a hollow cylinder of thick plate-iron, on which he laid a flat plate which might eaſily be removed when he wiſhed to view the veſſel.

The change of colour which takes place in a few minutes when a paſte of this kind is expoſed to air or oxygen gas, proceeded very ſlowly, but was eaſily viſible on the ſecond day. A depreſſion of the mercurial column was looked for, but did not take place on the third or fourth day, when it was diſcovered that the paſte had dried at the ſurface of the

mer-

mercury and had choaked the neck of the mattrafs.

No expectations being now entertained, the experiment was neglected.

On the third or fourth day after the laft obfervation, the Experimenter being fortunately engaged at the moft diftant part of the Laboratory, the mattrafs burft with a dreadful explófion; the iron plate which covered the mouth of the cylinder in which it ftood, was blown off, and the fragments of the glafs which ftruck upon wood were fixed in it.

At that time no fatisfactory explanation of the phenomenon could be given; but the difcoveries fince made, afford the following folution.

In this confined ftate of the pafte, the exhalation of its water was prevented; and there being no air to furnifh oxygen freely, that of the water was attracted and combined. The hydrogen of the water, now unreftrained, engaged Caloric to form hydrogen gas, which at a certain degree of accumulation and elafticity, burft the veffel.

EXPERIMENT V.

" In experiments like thoſe lately menti-
" oned, various impediments concur to retard
" the abſorption of the oxygen and the extri-
" cation of the Caloric. One of theſe ariſes
" from the diſperſion of the oxygen, in a tri-
" ple quantity of azote at firſt, and in a
" much greater relative quantity after-
" wards.

" In this latter circumſtance the oxyge-
" nous parts are the more weakly drawn
" from the fluid as they are diſtant from the
" attracting body; and their efforts to ap-
" proach it are reſiſted by the inertia of all
" the interceding azotic gas.

" This impediment is to be avoided, when
" we wiſh to ſhew the decompoſition of
" oxygen gas and the liberated Caloric moſt
" advantageouſly, as in the following expe-
" riments, which no one can view, and con-
" template with an unprejudiced mind, with-
" out being perſuaded that Caloric ſubſiſts in
" bodies, in great quantity and in a ſtate of
" perfect combination."

The

The vivid and rapid combuſtion of iron wire in oxygen gas, in the manner of Dr. INGENHOUZ, which is well deſcribed by LAVOISIER in the 87th page of Mr. KERR's Engliſh edition, was ſhewn on a large ſcale.

The tinder which ſerved to light the extremity of the coil of wire, was agaric well beaten and ſoaked in a ſolution of ſalt-petre, and then beaten and dried. Such tinder may be had of the Tobacconiſts.

The drops of melted iron and liquid oxyd which fell from the conical coil of wire on the bottom of the bottle, and even ſunk into the glaſs, broke it before the combuſtion ceaſed.

A better apparatus being ready the experiment was repeated.

EXPERIMENT VI.

A bottle open at the baſe and covered at the mouth with a double piece of bladder, was charged with three pints of oxygen gas procured from oxyd of mercury by calcination, and was placed on the ſhelf of a trough filled with mercury. A circular plate of iron being

being paſſed through the mercury, roſe above it, and covering its ſurface within the bottle, ſtood even with the ſurface of the mercury in the trough. The gas occupied only 4-5ths of the capacity of the veſſel, leſt any of it ſhould be expelled during the expanſion which was expected.

The proper ſtopper of this veſſel was provided with a mortoiſe-hole in which the iron wire was faſtened.

The wire was of the fineſt kind uſed in harpſicords, and was twiſted ſpirally to form a coil eaſily acceſſible to air in all parts, a quarter of an inch in diameter at the baſe next the ſtopper, and tapering downwards to the length of four inches to the point at which the tinder was fixed. This being lighted, the ſtopper was quickly introduced into the veſſel containing the oxygen gas, at the inſtant when the aſſiſtant had ſlidden away the piece of bladder which ſtopped it.

In this way of proceeding no atmoſpheric air could enter whilſt about half a cubic inch of heavier oxygen gas was preſſed out of the neck by the ſtopper and wire.

As the gas expanded and depreſſed the mercury during the firſt moments of the com-

combuſtion; the Experimenter holding the mouth and ſtopper, ſlid the veſſel from the ſhelf, and preſſed it into the mercury as faſt as the gas was conſumed; the heat in the mean time compelling him to place a piece of cloth between his fingers and the glaſs.

The combuſtion continued with the uſual phenomena; the iron plate receiving the drops of oxyd and melted ſparkling iron, until it roſe to touch the remaining part of the burning coil, within half an inch of the glaſs ſtopple. About this time the combuſtion firſt ſlackened and then ceaſed. The reſiduary gas contracted in cooling to the bulk of about four cubic inches.

Lime water introduced to it ſhewed that it contained Carbonic acid in ſufficient quantity to account for the ceſſation of the combuſtion before all the oxygen gas was conſumed. But the preciſe quantity was not aſcertained, becauſe it was intended in a future experiment to light the tinder in the veſſel by the focus of a lens.

It was obſerved that this experiment is liable to frequent failures by the cracking of the veſſel at the neck; and that the quantity of carbonic acid gas is variable, but

always

always ſufficient to prevent the combuſtion from proceeding to the total conſumption of the oxygen gas, for the reaſon aſſigned by LAVOISIER.

EXPERIMENT VII.

This was performed in the manner of LAVOISIER, page 88, and the reſult correſponded with his deſcription.

During the ſparkling and vivid combuſtion, attended with a perfect fuſion of the inflamed parts, the iron combined with the oxygen and formed a ſlag or oxyd which was brittle and pulverable when cold. Every hundred grains of iron united with thirty-ſix of oxygen, and the bulk of the oxygen gas was accordingly diminiſhed. The Caloric iſſuing rapidly all the while, appeared under the characters of fire and light; the former heating the veſſels, the latter dazzling by its brilliancy.

" In all decompoſitions of oxygen gas, " whether ſlowly effected as in the former " experiments, or rapidly as in the laſt, Caloric is extricated as certainly when it " eſcapes confounded with that of the tem-

" pera-

" perature, as when it cauſes the phenomena
" of fire and Light. But we are not there-
" fore to conclude with LAVOISIER that Light
" is alſo emitted in the former; whilſt there
" are ſtrong grounds for the opinion that Ca-
" loric acts as Light, by thoſe particles only
" which have acquired peculiar velocity in
" ſpringing forth from the ſtate of conden-
" ſation and coercion."

The Experimenter apologized for his manner of deſcribing theſe things, in conformity with his notions of Caloric and Light.

The place being incumbered with veſſels filled with azotic gas and oxygenous gas of the foregoing experiments, it was reſolved that they ſhould be expended at the next meeting in experiments on reſpiration.

No minutes were taken of the converſations of this evening, becauſe they took place in ſmall parties and on different ſubjects at the ſame time.

MINUTES

OF THE

EIGHTH MEETING,

ON

SATURDAY, March 22, 1794.

Experiments and Obſervations on the Reſpiration of Animals.

THE meeting was opened with a ſhort diſcourſe, in which the principal facts and opinions concerning reſpiration were mentioned, and the eminent philoſophers who had written on this ſubject were reſpectfully named.

EXPERIMENT I.

In the bell-glaſs *a b c d e f*, Plate II. fig. 1, the mouth of which at *a f* was an inch and a quarter in diameter, a ſlender circular

 maho-

mahogany grate was fixed horizontally at *b e*, on which a bird might reſt near *g*.

In this grate ſix feathers were ſtuck at equal diſtances and pointing downwards, in the manner *h i* and *k l*.

The mouth *a f* was flatted and accurately ground to the circular braſs plate *m n*, in the center of which the handle *o* ſtood upright. This plate when preſſed on the mouth *a f* made it air tight, and adhered ſtrongly when the lip of the veſſel was previouſly greaſed ſlightly with tallow.

The air being carefully excluded from the veſſel and the feathers, by ſinking them for ſome time in water, the plate was fixed on, and three wine pints of oxygen gas from red oxyd of mercury by nitrous acid, were introduced. The inſtrument with the gas being transfered to the ſhelf of a trough containing two gallons of lime water, this was made to aſſume a common level on the inſide and outſide of the bell glaſs near *c d*.

To introduce a ſparrow, which was ready, without admitting any of the external air, whilſt the plate was ſlidden ſideways, the bird's breaſt was made to ſtop the aperture, and at the inſtant of his entry the braſs plate

was

was flidden to its former pofition and fixed by preffure.

In this way the bird expelled its bulk of oxygen gas, which in its efflux prevented the entry of air; but he unavoidably carried in the quantity contained in his lungs and entangled in his feathers.

The veffel held by the mouth *a f*, was immediately removed from the fhelf to the deeper part of the trough, and by a circular ofcillatory motion of the part *c d*, whilft it was preffed a little into the water, this laft was made to wet the infide of the veffel to fome height at firft, and foon after the fides and feathers, as high as the grate on which the fparrow ftood. This agitation was repeated every minute in order to expedite the abforption of the carbonic acid gas, which the refpiration afforded, and which would foon have killed the bird, had it been permitted to remain in the oxygen gas. The lime water became turbid wherever it remained for a few minutes undifturbed on the fides of the veffel, but the precipitation of the whole was not fo perceptible. On this fubject it was faid that the quantity of Carbonic acid gas produced in refpiration is much fmaller

than has been heretofore imagined, and in the preſent experiment is not ſufficient for the total precipitation of one tenth of this lime water.

After the firſt emotions excited by the novelty of his ſituation, the bird ſhewed no uneaſineſs in the courſe of two hours or more; the lime water continuing all the while to approach to the grate as faſt as the oxygen gas was conſumed.

The gentlemen now unanimouſly demanded that he ſhould be ſet at liberty, before the lime water ſhould reach him. They added that the experiment was already concluſive in reſpect to the eminent reſpirability and the ſalubrity of oxygen gas, and the total expenditure of it in reſpiration, when the carbonic acid gas is thus quickly withdrawn from it.

The cover being removed and the grate withdrawn after the veſſel was dried, the bird flew away with great vigour.

The Experimenter expreſſed his intention to repeat this experiment with a veſſel of the ſame capacity, but having the compartment above the grate reduced to one fourth of the ſpace in which the bird was lately placed. He intended alſo to permit the bird to remain until

until the bulk of the refiduary oxygen gas fhould be reduced to about two ounce meafures; and then to examine this refidue, which may be expected to confift of oxygen gas mixed with as much azotic as the bird had introduced.

The great fize and peculiar communications of the refpiratory organs of birds warrant the expectation that the bulk of azotic gas thus introduced will equal half that of the naked birds. The experiment fucceeded accordingly.

EXPERIMENT II.

" The character of azotic gas is quite the
" reverfe of the foregoing. Mice and other
" animals are fuffocated in it in a few fe-
" conds. They generally die in it in lefs
" than the time during which they could
" bear an interruption of their refpiration.

" If a moufe when he droops in azotic
" gas be immediately withdrawn from it, he
" may be recovered by applying a finger
" moiftened with aqua ammoniæ puræ to
" his nofe and lips, and by chafing him
" with the hands. It is expected that the

" bird which is now to be employed will be
" ſaved in the ſame way, as the veſſel may
" be opened at both ends, and atmoſpheric
" air may be blown through it in two or
" three ſeconds."

The inſtrument uſed in the laſt experiment, being filled with azotic gas procured from air by the means of iron filings and ſulphur paſte, and purified by expoſure to lime water, a freſh ſparrow was introduced with the utmoſt celerity. He fell dead in a ſecond; and although the inſtrument was quickly raiſed, and air was blown through it in leſs than three ſeconds, the meaſures above mentioned could not recover him, neither did blowing gently into his lungs avail. Thus it appeared that animals which have large lungs adapted to the reſpiration of the open air, are ſooner ſuffocated in azotic gas, than thoſe which are uſed to live under ground.

EXPERIMENT III.

Azotic gas was taken from the veſſel which ſupplied that by which the bird was killed; and being mixed with the quantity of oxygen

gas

gas which was neceſſary for the compoſition of atmoſpheric air, the mixture was tranſfered into the veſſel uſed in the preceding experiments.

A freſh ſparrow being introduced and the veſſel agitated in lime water as in the firſt experiment. He breathed eaſily at firſt, but afterwards ſhewed ſigns of diſtreſs, whilſt the bulk of the air diminiſhed. When about one half the oxygen gas had been expended, he would ſoon have died, had he not been recruited with freſh oxygen gas.

It was obſerved that a mouſe could live to conſume much more of the oxygen gas, in this circumſtance; and that oxygen gas adminiſtered in due time, never fails to revive him.

" In ſuch experiments no conſiderable di-
" minution of the bulk of the azotic gas has
" been diſcovered. And however noxious
" it be when pure, it always ſeems to be
" merely paſſive in reſpiration, ſo long as
" oxygen gas remains in it in due quantity."

As it was known to all, that animals ſuch as birds and mice, whoſe natural reſpiration is quick and uninterrupted, are almoſt inſtantly ſuffocated in carbonic acid gas; and as it was

admitted on the authority of philoſophers whoſe veracity and ſkill are unqueſtionable, that carbonic acid gas produces this effect ſooner or later, according to the quantity of it, when mixed with air, or even with oxygen gas; it was deemed ſufficient to ſhew that carbonic acid gas poured from a wide mouthed bottle, ſinks in the air by its greater ſpecific gravity, and extinguiſhes a taper placed many inches below the bottle.

"From theſe properties of carbonic acid "gas we learn how an animal is ſoon ſuffo-"cated in a veſſel containing as much oxygen "gas as would ſerve for reſpiration for many "hours; and the ſooner as he is placed low-"er in the veſſel, where the carbonic acid "gas chiefly gathers."

Dr. Powel's queſtion reſpecting Carbonic acid gas, at the ſixth meeting, was the chief ſubject of converſation this evening. The Editor obſerves with great regret that the minutes do not enable him to give a correct account of the converſations, or to do juſtice to the ſpeakers.

The

The minutes exprefs no more than that Mr. YOUNG related an experiment, in which he placed infects (probably wafps) in carbonic acid gas. He defcribed their peculiar organs of refpiration at their fides: and faid the effect of the gas was to render them torpid at firft and afterwards ftupified. This effect ceafed after a while, and thenceforward they feemed to fuftain no inconvenience from the carbonic acid gas.

Several members made obfervations and conjectures on this fubject, which were not entered in the minutes. The Editor recollects one which was to the following effect.

Acid gas, which is generally fuppofed to caufe fuffocation by irritating and caufing a ftricture of the mufcles of the Larynx; may not affect an animal of this ftructure, who perhaps is not provided with fuch mufcles, the chief ufe of which is to modulate the voice; or who may have his heart fo conftructed that his circulation may be carried on without refpiration.

Another member obferved that Dr. POWEL was aware of thefe opinions, and yet perfifted in his queftion.

The Experimenter on this occafion related

the

the effects of divers things on respiration. He spoke first of astringents and particularly of the rind of nuts: then of acid vapours: next, of the imminent danger of suffocation, which he once experienced from the exhalation of oxygenated muriatic acid.

Whilst he was cautioning a gentleman against this insidious enemy, and inattentive to himself, he felt no immediate inconvenience. But in a few seconds after he had retired from the place into fresh air, he had a sense of stricture in the Larynx, which encreased for two or three minutes, until he was almost suffocated. He swallowed water repeatedly, and then milk; and at last was glad to swallow oil. The difficulty was in the inspiration which was extremely slow and stridulous; for he could expire as much air in two seconds, as he could inspire in twenty.

Lastly he related two cases of poisoning by laurel water; in both which the parties poisoned were manifestly strangulated by a stricture of the Larynx.

Dr. Powel said that he was now engaged in experiments tending to decide on this question, and that he should at present

ſent content himſelf with relating the following.

He made an animal to breathe through a Canula placed in the Trachea, below the muſcles of the Larynx; and yet he was deſtroyed preſently by the carbonic acid gas. He would not now draw any inference; but obligingly promiſed to give further information on the ſubject.

MINUTES

OF THE

NINTH MEETING,

ON

SATURDAY, March 29, 1794.

Experiments and Observations on the Respiration of Men.

EXPERIMENT I.

"MR. CAVENDISH to whom we are indebted for the greatest of the modern discoveries in Chemical Philosophy, many years ago observed that the oxyd of mercury by nitrous acid may be made to yield oxygen gas fit for experimental use."

The expence of oxyd by calcination, and the great consumption of oxygen gas in the laboratory every year, having induced the Experimenter to prepare the oxyd by nitrous acid with the greatest attention to œconomy and

and perfection; he referred to the books of the laboratory for the necessary information respecting the operations which were now carried on for these purposes.

It was there stated, in reference to the process of the Pharmacopœia, that nitrous acid much less expensive may be used. Twenty-nine parts of suphuric acid being insufficient for the decomposition of sixty of nitre, a considerable quantity of the nitre remains undecomposed. But if the heat be greatly augmented to decompose it by Caloric, the product is not condensible. A much greater quantity of nitrous acid equally fit for the nitrat of mercury, may be obtained from a charge consisting of sixty parts of nitre and thirty-five of sulphuric acid.

To sixty ounces of this acid placed in a deep porcelain dish standing on a flat tile in a muffle, an equal quantity of mercury is to be gradually added. The dish is to be covered with a plate of glass during the solution, and a small aperture on the side of the muffle is to be left open to pass away the nitrous gas and vapour, through the chimney. On the next day, when the solution has been compleated, the muffle is to be gradually heated

until

until the nitrat becomes dry, after which the heat is to be ſlowly raiſed in the courſe of 24 hours to 600°.

The nitrat thus prepared is uniform in colour and quality in all parts; which never is the caſe when it is heated in a ſand bath; in which the ſuperficial and central parts of the oxyd remain yellow, even when the heat at the bottom and ſides has been ſufficient to decompoſe a part of the oxyd firſt formed.

As the nitrous acid always contains ſome quantity of muriatic acid, corroſive muriat of mercury always exhales during this proceſs, and a little of the nitrat of mercury itſelf is carried forth along with the nitrous gas and vapour.

In the uſual method of preparing the oxyd in the laboratory of a teacher, the place becomes ſo ſtrongly impregnated with mercury in a very active ſtate, in ſpite of all that can be done by receivers and ventilation, that any man who ſpends much time in it, is ſure to feel the effects of mercury; and if he ſhould employ himſelf in the mean time, in breathing the oxygen gas procured from the red oxyd, he is apt to impute theſe effects to mercury contained in the gas. A very re-

respectable author has fallen into this error.

When this oxyd is made to yield oxygen gas through water, in the manner formerly described, and is kept for 24 hours in bottles properly stopped, all the mercury is saved: the expence consists only in the waste of nitrous acid, and the gas may be breathed in any quantity with perfect safety.

It was the opinion of the Experimenter that the red oxyd may be prepared with two thirds of this quantity of acid, provided a little water be used, and the solution of the mercury be very slowly effected in a deep vessel, in which the nitrous gas may meet air to form it into nitrous acid, and return it into the charge.

EXPERIMENTS II. III.

An instrument by which a man may breathe any quantity of air or oxygen gas was now produced. It was the same which was first used by the Experimenter in 1786, and differed only in the size, from the following which is represented at Plate II. fig. 2.

a b c d

a b c d reprefents a bell-glafs terminating at the top in a narrow neck, on which the perforated brafs cap *a e f d* is cemented.

The brafs ftop-cock *e g h* fcrews into the cap at *e f*; and into a fimilar brafs cap *h i*, a tube of iron-wood *h i k* is cemented. The end at *k* being made large and flat, in order that it may be more firmly embraced by the lips of the perfon who refpires through it.

The aperture of the tube from *a d* to *k* is uniform and one fourth of an inch in diameter; this being found fufficient for free refpiration.

The cock at *g* being ftopped when the veffel was filled with clear lime water in a large trough; oxygenous gas from the oxyd of mercury by nitrous acid, was introduced to the quantity of nineteen pints. The veffel buoyed up by the gas, was held upright, fo that the tube *g k* prefented itfelf tranfverfely by the end *k*, to Mr. TAYLOR's mouth.

He was prepared, by affuring himfelf that he could force no air from the fauces through the ears; and that the fpring-clip, which he fixed on his nofe, had clofed the noftrils effectually. Then expiring all the air he could expel from his lungs, in a bent pofture of the body,

body, he took the mouth-piece of the tube into his mouth, and preſſed his lips on it with one hand, whilſt he held the ſtop-cock with the other.

The tube being filled with water between *g* and *k*, he took care to draw this gently into his mouth, when he opened the cock; and in breathing the gas afterwards, he ſuffered the veſſel to play freely up and down with the motion which the reſpiration gave it.

An aſſiſtant at this time held, in the lime water, by the ring *f e*, Plate II. fig. 3. the iron wire, bent to the figure *a b c d e f*, and carrying, at the end *a*, feathers faſtened in a radicated form *a g h*.

The feathered leg of this wire being introduced into the veſſel containing the oxygen gas, whilſt the leg *c d e* ſtood outſide of it, he made the feathers to riſe and ſink alternately, ſo as to expoſe freſh ſurfaces of lime water to the gas, in quick ſucceſſion during the reſpiration.

This expedient was deemed neceſſary at the time, in order to accelerate the abſorption of the carbonic acid gas produced in reſpiration.

The bulk of the oxygen gas was viſibly diminiſhed at every reſpiration, and the lime

 water

water became turbid. Mr. Taylor being desired to respire slowly, and without pressing the vessel into the lime water, nevertheless consumed the whole of the oxygen gas in six minutes. He did not stop until the lime water had risen into his mouth.

Although Mr. Taylor was healthy, and his age about 22; his natural pulse was only 64 previous to the experiment, and not more than 66 on the following day.

During the respiration, his pulse quickened to 90 beats in a minute and was considerably encreased in fullness and strength: But he felt no inconvenience whatever.

The vessel being immediately charged again with 19 pints of gas, he respired these also, and consumed them entirely in six minutes. His pulse was increased to 120 beats in a minute, and was vigorous withal. He felt no inconvenience; but had a sense of unusual warmth in his lungs. In one hour after the experiment his pulse returned to 64.

The inferences were deferred to a future meeting.

A converſation enſued, in which many of the members ſpoke on the fatal effects of crowded rooms and priſons, in which the air gradually exhauſted of oxygen gas by reſpiration, and charged with carbonic acid gas, firſt becomes inſufficient for the due maintenance of the animal functions, and ſoon after ſuffocating by the carbonic acid gas.

Inſtances were mentioned of perſons ſuffocated by ſleeping in cloſets and cloſe rooms, in which charcoal had been left burning, in order to warm them: and the effects were juſtly attributed to the expenditure of the oxygenous part of the air, in the formation of deleterious carbonic acid gas.

The unwholeſome luxury of nocturnal aſſemblies, cloſe rooms, and numerous candles was noticed. And then a deſultory converſation on the diving-bell took place.

A member who was acquainted with the diver who went twenty or thirty feet under water, and between decks in the Royal George, and was employed in raiſing ſome of the ſtores or guns; deſcribed this art as conſiſting chiefly in his uſing a light portable wooden veſſel not unlike a bell, which covering the diver's body as low as his hips,

took down with him air enough to ſerve for reſpiration, until he turned in more from barrels of air ſent to him with the bung-holes downwards, by means of the machinery. When his bell was full it preſſed on him with a weight of only 14lb. He ſaid he could detach it from the tackle, which he took care to faſten where he could eaſily find it; and after walking between decks, could fix it to the tackle again, in order to be drawn up.

The only inconvenience he ſuſtained under the additional preſſure of ſuch a column of water, was felt in his ears, and during the time of his deſcent; and this was imputed to the preſſure on the Tympanum.

He was ſuffocated in his diving-bell, whilſt he was attempting to raiſe valuable ſtores from a veſſel which was ſunk on the coaſt of Ireland; and as he was very expert and intrepid, his death was imputed to his piercing or ſtaving a veſſel of ſome fermentable matter ſuch as biſcuit or fleſh, which furniſhed carbonic acid gas in ſufficient quantity to ſuffocate him before he could give the ſignal for raiſing him.

A viſitor mentioned an inſtance lately diſcovered, of combuſtion without the aid of oxygen. He ſtated the experiment in general terms, and afterwards communicated the particulars of it by Mr. YOUNG, in the following words.

" Forty-five grains of braſs filings and " fifteen grains of flowers of ſulphur previ- " ouſly dried, are to be melted into a cake. " This being placed in mercury, with a veſſel " void of air inverted over it, will take fire " and burn when the mercury is heated."

In the converſation which aroſe on this ſubject, Dr. LATHAM mentioned the combuſtion which takes place at the ſurface when phoſphuret of Lime is thrown into water. Another member obſerved that the oxygen of water and the external air, act in this latter inſtance; and that no water or air is preſent in the experiment with braſs filings and ſulphur.

The Society being informed that the experiments yet to be offered on the ſubject of reſpiration could not all be made in the courſe of the next meeting; but that the reſult of ſuch as might be performed by the Experimenter in the mean time with the inſtruments already deſcribed and uſed, might be conciſely reported in the minutes; he was directed to proceed and report accordingly.

MINUTES

OF THE

TENTH MEETING,

ON

SATURDAY, April 5, 1794.

Experiments and Observations on the Respiration of Men.

IT was intended that the Carbonat of Lime, precipitated from the Lime water during the respiration of thirty-eight pints of oxygen gas by Mr. TAYLOR, at the last meeting, should be collected, and that the quantity of carbonic acid gas produced in that process should be ascertained, by detaching it from the Carbonat in close vessels. But the attempt was attended with insurmountable difficulties, arising from the use of a wooden trough, and the smallness of the quantity of the precipitate relatively to the mass of lime water,

 which

which had neceſſarily preſented an extenſive ſurface to the air, and had contracted a thick pellicle.

EXPERIMENT I.

A tall clylindrical tin veſſel was therefore provided; the capacity of which was not more than twice greater than that of the bell-glaſs containing the oxygen gas. In this ſmaller veſſel charged with lime water, the following experiments were made.

In the manner deſcribed in the minutes of the laſt meeting, the Experimenter reſpired 19 pints of the like oxygen gas, until the lime water roſe into his mouth. But all the while, he preſſed on the veſſel with force enough to raiſe the ſurface of the external lime water eight inches at an average above the ſurface in the bell-glaſs; and thus he reſpired the oxygen gas under the preſſure of an eight inch column of water added to that of the atmoſphere.

The gas was conſumed in four minutes and 45 ſeconds, by long and deep inſpirations at firſt, and the ſhorter and quicker which he was obliged to make at laſt, leſt

lest the lime water ſhould ruſh into his lungs.

He felt no inconvenience from this rapid conſumption of the gas. The lime water was found ſtill to retain the chief part of its lime, and to have depoſited but very little carbonat of Lime.

EXPERIMENT II.

In about half an hour afterwards he breathed nineteen pints more of the oxygen gas, expoſed to freſh lime water; taking care in the mean time to ſuſtain the veſſel, ſo that the preſſure on the oxygen gas ſhould be as much leſſened in this, as it was increaſed in the former experiment.

Under this circumſtance the reſpiration was very laborious, and continued for about eleven minutes, before the whole of the gas was conſumed. The difficulty encreaſing towards the end, obliged the Experimenter to lower the veſſel a little in the lime water, occaſionally.

The precipitate from the lime water ſeemed to be greater in this than in any former experiment

ment with this inſtrument. But ſtill the lime water was not compleatly precipitated.

For this and divers other reaſons, it was intended that this experiment ſhould be repeated, with leſs lime water.

EXPERIMENT III.

The inſtrument being charged again with nineteen pints of the like gas, expoſed to freſh lime water; the Experimenter breathed the gas as Mr. TAYLOR had done, under a preſſure intermediate between that of the firſt and ſecond experiment of this meeting; and conſumed the whole of it in ſix minutes and a quarter.

The inferences were deferred to the next meeting.

The Experimenter now begged leave to inform the ſociety that he had performed the experiment propoſed by a viſitor, at the laſt meeting and afterwards deſcribed in a note by Mr. YOUNG; with a double charge

of

of the braſs filings and flowers of ſulphur; but with due care to expoſe the materials to air, no more than was unavoidable.

The maſs conſiſting of the ſulphur melted into the filings of braſs, was introduced under mercury into a dry and warm glaſs jar previouſly filled with mercury and inverted in it; in the preſence of Dr. LATHAM, Dr. POWEL, Mr. YOUNG and Mr. GRUBB; and the mercury was then heated to the boiling point: but nothing like combuſtion took place, although the heat was ſufficient to make the mercurial vapour fill the jar, after depreſſing the mercury in it to the common level. For a while it was ſuſpected that a gaſſeous fluid had been generated, and had produced this depreſſion of the mercury; but as the whole cooled, the mercury roſe nearly to its former height; ſhewing that the depreſſion was owing to mercurial or ſulphurous vapour and nothing elſe.

On the next day about half a cubic inch of elaſtic fluid was found ſtill remaining above the mercury; but this was regarded as the quantity of air which ſuch a porous mixture might eaſily have retained until it was heated.

The Experimenter would have repeated this

this proceſs with the braſs filings and ſulphur formed into a matt or intimate combination, by fuſion in a greater heat; were it not conſidered as utterly incompetent to the proof of its capacity to catch fire and burn without the aid of oxygen; becauſe ſuch a matt cannot be made and applied without contact with air, which it powerfully attracts.

A member who made this experiment in the foregoing manner, ſaid that he had obſerved more elaſtic fluid over the mercury in the courſe of three or four days, but ſaw nothing like combuſtion.

It was anſwered that this might eaſily have happened in a moiſt veſſel, as ſulphurated metals imbibe water, and in ſome circumſtances decompoſe it; but the product would be Hydrogen gas, or ſulphurated Hydrogen gas.

It was declared that any experiment propoſed on proper authority, ſhould be made, however unpromiſing it might be, under the philoſophical opinions now entertained.

MINUTES

OF THE

ELEVENTH MEETING,

ON

SATURDAY, April 12, 1794.

Experiments, Obſervations and Inferences concerning Reſpiration and Animal Heat.

MR. LAVOISIER and DE LA PLACE made their experiments on Guinea-pigs, by introducing them into oxygen gas, and withdrawing them in due time. To the vitiated oxygen gas they preſented a ſolution of cauſtic alkali; and after all the carbonic acid gas was abſorbed, the animals were returned to breathe the purified oxygen gas. By repetitions of this proceſs, it was found that the whole of the oxygen gas may thus be conſumed.

As theſe animals muſt introduce air in their

their lungs as often as they are reurned into the oxygen gas, this method is not so eligible as that of the experiments lately presented.

Dr. Priestly, Dr. Crawford and others observed, that when atmospheric air thus employed was confined by mercury, its bulk was not considerably diminished by the respiration of mice or Guinea-pigs, which were left to expire in it. In this case, the Carbonic acid gas concurs with the azotic to suffocate the animal, and at the same time serves towards the maintenance of the original bulk of air.

A Guinea-pig lives about 42 minutes in five pints of atmospheric air confined by water; and although the carbonic acid gas be withdrawn, the animal expires when about 3-4ths of the oxygen gas have been consumed.

A mouse placed in a smaller quantity of atmospheric air proportionate to his size, lives longer; but expires when a little more than 3-4ths of the oxygen gas have disappeared, although lime water be used.

Sparrows die in air confined by lime-water, before they have consumed two-thirds of the oxygen gas.

Frogs

Frogs and amphibious animals whofe circulation can be carried on for a long time, without the aid of refpiration, by reafon of the ftructure of their hearts ; and who fubfift by the fmalleft quantities of oxygen gas, live longeft in confined air.

Frogs can ftop their refpiration for forty or fifty minutes, and therefore do not die even in carbonic acid gas in lefs than fifty minutes.

Birds confume the oxygen gas of air more quickly than other animals of equal bulk ; their refpiratory organs being much larger.

Birds and other animals, who are formed to live in open air, expire fooner in air vitiated by their refpiration, than thofe animals that are defigned for living occafionally in clofe places.

The azotic gas has been confidered by all as a mere vehicle or diluent of the oxygen gas, and paffive in the refpiration of air. No one has obferved any diminution or confumption of it, either by combining in the manner of the oxygen gas, or by penetrating the veffels of the lungs, to mix with the circulating blood.

After numerous experiments made with the

the views lately expressed, and for purposes which are presently to be mentioned, modern philosophers agree in the following facts and inferences.

The azotic gas of atmospheric air is not only unfit for respiration, but quickly destructive to animals who breathe it: although $\frac{73}{100}$ of respirable and salubrious air, consist of azotic gas.

Oxygen gas is the part of the air which is indispensably necessary for the maintenance of the animal functions dependent on respiration.

Since the respiration of pure oxygen gas was found, in the experiments of the two last meetings, to produce a preternatural heat in the lungs, and a rapid febrile pulse, such as always tends to the dissolution of the animal frame: and since debility, convulsion and death follow the successive diminutions of the oxygen gas of air, by respiration, long before the whole of the oxygen has been consumed; although the carbonic acid gas be in the mean time carefully withdrawn: we may safely conclude that the natural proportion of these gasses in the circulating air, is the fittest for breathing animals; and that

any

any confiderable increafe or decreafe of its oxygenous part would render it lefs falubrious to animals in general.

Various effects are produced in the animal fyftem by the refpired oxygen gas, the chief of which is the production of *animal heat*.

On this fubject Dr. CRAWFORD is to be efpecially confulted; for he made the firft advances towards a fatisfactory theory, and afterwards in 1788, publifhed an elaborate work in which he availed himfelf of all the recent improvements made by cotemporary Experimenters, in this department of phyfical knowledge.

In attempting to give a fketch of the theory of Animal heat, the Experimenter would avoid whatever is expreffed or argued under the opinion *that Caloric is not chemically combinable in bodies*; and would alfo omit all that has been inferred from the different capacities of arterial and venous blood in regard to heat; for reafons which are to be fhewn hereafter.

In all oxydations by oxygen gas, in which

 metals

metals become calciform; Sulphur, Phoſphorus, Carbo, and other Acidifiable baſes, become acids; and hydrogen forms water; the oxygen gas is partially or totally decompoſed; and the exceſs of Caloric, beyond the quantity combinable in the oxyd, is expelled.

The oxyd or product is the ſame whether the proceſs be quick or ſlow. This may be exemplified in all, but moſt eaſily in Phoſphorus. For this forms the ſame acid with oxygen gas, whether it be burned ſo quickly as to heat intenſely, or ſo ſlowly as to cauſe no perceptible augmentation of the common temperature.

The combinations of oxygen drawn from the air, are extremely numerous in the various proceſſes of calcination, combuſtion, ſlow oxygenation of ſulphurets and carbonaceous and oily bodies, acetous fermentation, and putrefaction; in all which Caloric is extricated during the union of the baſe of oxygen gas with the attractive ſubſtances.

Reſpiration ranks amongſt the proceſſes which ſhew the quickeſt expenditure of oxygen gas; and the quantity of water and carbonic acid gas produced during this expenditure, ſhews that the extricated Caloric is

ſuf-

ſufficient to produce all the incaleſcence of the organs in which the combination of the oxygen is effected.

The blood is formed from animal and vegetable ſubſtances, and like them abounds in Carbo and Hydrogen, and alſo contains phoſphoric matter. All theſe principles ſtrongly attract oxygen and tend to the extrication of Caloric from the oxygen gas preſented to them.

This property of the blood appears, under the moſt diſadvantageous circumſtances. For when drawn from an animal and inſpiſſated by cold and reſt, it is ſtill capable of contracting the volume of oxygen gas, by combining with the oxygen: and venous blood of a deep livid red colour, when expoſed to oxygen gas, acquires the vivid red colour, by which arterial blood which has recently paſſed through the lungs, is diſtinguiſhed from the venous blood returning from the extremities.

Anatomiſts and Chemiſts have frequent experience of the facility with which thin membranes and veſſels, ſuch as thoſe of the lungs, are pervaded by elaſtic fluids; eſpecially under the circumſtances of moiſture and

 preſ-

preſſure; and can eaſily perceive how ſuch veſſels may eaſily admit oxygen gas to the blood, and as eaſily permit a carbonated hydrogenous fluid to meet the reſpired air in the Bronchial ramifications, under circumſtances highly conducive to their union. Theſe circumſtances are preſſure, capillary attraction, motion and heat.

Any proceſs in which oxygen gas loſes its gaſſeous form, and depoſites its baſe in an attractive ſubſtance, and therewith forms carbonic acid or water, is to be conſidered as a ſpecies of combuſtion. The materials, the products, and the liberation of the Caloric being the ſame ultimately, whether the operation be attended with viſible fire by reaſon of the velocity, or only with ſucceſſive and weak incalence, when the progreſs of it is ſlow.

Reſpiration therefore is to be conſidered as a ſpecies of combuſtion, in which the lungs ſupply the fuel and force the air upon it; and in which the extricated Caloric is diffuſed through the ſyſtem by the circulating blood; none of it eſcaping, as in rapid combuſtions, in the form of Light.

Dr. Crawford acknowledges that if Caloric

loric be chemically combinable with bodies, his menſurations of it are defective.

If the matter of Caloric and Light be the ſame, all the menſurations of Caloric from flaming and glowing bodies are alſo defective: and on both theſe grounds, excluſive of others which we need not mention at preſent; the comparative eſtimates of the Caloric of burning bodies, and of reſpiration, are to be conſidered only as approximations to the true quantities.

The experiments of Mr. LAVOISIER and DE LA PLACE with their Calorimeter, and thoſe of Dr. CRAWFORD with a different inſtrument, agree ſufficiently to ſhew that, the quantities of oxygen gas being equal, more heat is produced in the combuſtion of Hydrogen gas and Phoſphorus, than in that of Carbonated hydrogenous bodies which yield Carbonic acid gas and a little water; and more in the combuſtion of theſe, than in that of Charcoal, which may be ſaid to yield carbonic acid gas only.

This is perfectly conſiſtent with our knowledge of the quantity of Caloric combined in gaſſes, and neceſſary to the gaſſeous ſtate of the carbonic acid of theſe combuſtions.

In like manner theſe excellent Philoſophers meaſured the heat produced during the conſumption of oxygen gas, by Guinea-pigs; and due allowance being made for the heat carried off with the perſpiration of theſe animals, their experimets agree ſufficiently to prove that, the quantities of oxygen gas being equal, the heat produced by reſpiration, is nearly equal to that of the combuſtion of oily bodies, which yield a little water along with the carbonic acid gas in this proceſs.

The quantity of oxygen gas conſumed by a man, in reſpiration, is found to be nearly equal to that conſumed by a candle in the ſame time. And thus a man derives as much heat continually from the air which he breathes, as is produced by the burning of a candle.

It is therefore ſufficiently evident that animals derive their heat from the air, or to ſpeak more ſtrictly, from the Caloric of the decompoſed oxygen gas of the reſpired air; whether this decompoſition be effected in the Bronchial air-veſſels only, or partly in the ſanguiferous veſſels throughout the ſyſtem, in conſequence of the entrance of a portion of the

the oxygen into the blood veſſels of the lungs. This laſt is not at all admitted by Dr. Crawford.

This knowledge of Reſpiration, and Theory of Animal heat, affords many ſatisfactory explanations and uſeful inferences; a few inſtances of which are now to be mentioned.

The temperature of animals which are furniſhed with lungs, and continually reſpire freſh air, is conſiderably higher than that of the ſurrounding atmoſphere; whilſt animals which are not ſo furniſhed, and amphibious animals which require but a little air at long intervals, are nearly at the temperature of the medium in which they live; becauſe the heat is proportionate to the quantity of oxygen gas reſpired and decompoſed.

For the ſame reaſon the breathing animals which have the largeſt lungs are the warmeſt; and birds exceed all animals of equal ſize, in their natural temperature.

Joy, Anger, Exerciſe, and whatever accelerates the return of the blood, and compels animals to breathe oftener, encreaſes their temperature.

When the temperature of an animal is increaſed by quick reſpiration, or by the aſ-

ſiſtance of a warm medium; the exhalation from the lungs and the whole ſurface of the body is at the ſame time encreaſed, and the further augmentation of the heat is thereby prevented.

When the heat of an animal is quickly diſſipated in a cold medium, as in froſty weather; the denſer air ſupplies oxygen gas more abundantly, in each reſpiration; the conſtruction of the extreme veſſels cauſes a quicker return of the blood to the heart, and urges to a quicker reſpiration; and the cold cauſing a ſtricture of the perſpiratory organs, leſſens the expenditure of heat by theſe channels, whilſt the generation of it is increaſed by the preceding cauſes. The Animal at the ſame time affects exerciſe, or avoids the current of air when it is extremely cold.

Active men ſuffer nothing from cold air, in compariſon with the ſedentary or indolent; for the muſcular motion of the former, accelerates their circulation, reſpiration and generation of heat; whilſt the latter, reſpiring weakly and ſlowly, become languid and chilled, and ſeeking ſhelter from the cold air; in cloſe places, and conſequently in air which they ſoon vitiate, become enervated pale and ſickly.

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The rational reſource in a caſe of this kind, conſiſts in warm cloathing; if exerciſe cannot be attained.

As the maintenance of the animal functions, the vigour, the circulation, the florid colour of the blood, and the fluidity of it, depend in a great meaſure on the free and full reſpiration of unvitiated air; the countenance of the Peaſant is florid in compariſon with thoſe of the luxurious; who enjoying but little of the Light of the ſun, and of the ſalubrious morning air, live in rooms highly illuminated and contaminated with candles and reſpiration, and ſleep in air confined by curtains.

Since the caloric extricated in reſpiration, is adequate to the production and maintenance of Animal heat: ſince the heat of animals is proportionate to the oxygen gas decompoſed: and ſince, in the ſame animal, the heat encreaſes and decreaſes with the conſumption of the gas: we have the ſtrongeſt phyſical proofs that animal heat is derived from the Caloric extricated during the oxygenation of animal matter in the Bronchial ramifications, and perhaps in the ſanguiferous veſſels.

It is by no means neceſſary to the ſupport of this doctrine of Animal Heat, that we ſhould

ſhould follow Dr. CRAWFORD in his opinion that none of the oxygen enters the blood; or in his ſuppoſition that Caloric is not extricated from the blood or from combuſtible ſubſtances, during the proceſſes of reſpiration and combuſtion.

The Experimenter expects, it will hereafter appear, that the proofs of the combinations of Caloric in blood and in combuſtible bodies, are too ſtrong to be combated by the menſurations of Capacities for heat, which, however ſpecious and ingenious, are very exceptionable, if not very fallacious.

The Count DE MILLY, Mr. FOUQUET and others have obſerved that Carbonic acid gas tranſpires from the whole ſurface of the body, along with the aqueous perſpirable matter; and it would be repugnant to general Analogy, and to our knowledge of the ſtructure of the lungs, to ſuppoſe that the like perſpirable matter does not iſſue more copiouſly from the Bronchial ſurfaces, independently of the reſpiration of the moment.

Dr. CRAWFORD's menſurations of the Carbonic acid gas of reſpiration, were taken from experiments, in all which, the animal not only breathed but perſpired in the confined air or

oxy-

oxygen gas. These were therefore apt to exhibit more than the quantity of Carbonic acid gas recently produced by the respiration merely.

He nevertheless found that the whole of it was insufficient to account for the oxygen gas consumed; and being averse to the opinion that some of the oxygen entered the lungs and passed into the circulating blood, he concluded that $\frac{1}{5}.7$, or $\frac{1}{6}$ of the oxygen gas was expended in the formation of water.

The Experimenter had two years before stated an expenditure of this kind at $\frac{1}{3}$ of the oxygen gas; suggesting at the same time, that a portion of it entered the blood.*

He is now of opinion, that the experiments to be made with a new instrument, will shew, that in respect to the respiration of man, the truth lies between these extremes,

* Experiments and Observations, 1786, page 352.

In the experiments of the laſt meeting, the effect of preſſure is to be particularly noticed. Under the greateſt preſſure the oxygen was conſumed in leſs than half the time of the ſmalleſt; although the exceſs of the former above the latter, was much leſs than that which men experience in the common changes of weather.

The Bronchial ſurfaces expoſed to the oxygen gas, and the ſtructure of the lungs, being the ſame in theſe experiments, the great difference in the expenditure of oxygen gas, cannot be eaſily accounted for, unleſs by admitting that ſome oxygen enters the blood veſſels, and that this percolation is accelerated by preſſure.

But if the percolation be doubled by ſo ſmall an increaſe of preſſure, it is highly probable, that in ordinary reſpiration and under the uſual preſſure of the atmoſphere, oxygen gas conſtantly paſſes into the blood in ſome ſmaller quantity, and that the fluidity and florid colour which the blood acquires in the lungs, is produced rather by the oxygen which it has received, than by any thing which it has emitted from the lungs.

By the aid of the inſtrument which is preſently

ſently to be ſhewn, it is expected that the doubts which envelope this ſubject will be cleared; and that the oxygen gas will be found to miniſter to health and life, by the Caloric which it imparts to the blood in the lungs and in the arterial ſyſtem, by the action of its baſe in the blood, and by the abſtraction of Carbonic and Hydrogenous matter from the lungs.

In the mean time it may be remarked that, without any diſtinct knowledge of the effect of preſſure on the air in reſpiration, Men, as it were inſtinctively, practiſe it under debility, languor, grief and pain.

Inſtead of reſpiring quickly to augment the heat in the lungs, and accelerate the circulation, they have recourſe to ſighing and ſobbing. In ſighing the breaſt is highly raiſed to draw a long and full inſpiration; the air is retained and compreſſed for a ſecond or two, and is then expelled by a forced expiration. In ſobbing, the air compreſſed in the ſame way, meets frequent concuſſions from the ſpaſmodic agitations of the breaſt. A deep ſigh brings the quickeſt relief to an oppreſſed heart: and in the laſt efforts to maintain the vital ſpirit, a man breathes with

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an elevated breaſt, and in compreſſing the air, makes an interrupted and ſonorous or groaning expiration.

The hopes entertained in reſpect to the medicinal uſe of oxygen gas, are heightened by the probability of its acting in the ſyſtem, beyond the lungs; and ſtill more by the experiments which prove that its effects may be encreaſed to a very great degree, by preſſure.

In the temperate and northern climates, men are afflicted with the gout, whether they live in the country or in town, on vegetable or on animal food, in warm or in light cloathing. The beſt means of averting the gout, are generally known to conſiſt in daily habitual exerciſe and temperate living. Between theſe, and violent exertions, by hunting or play ſucceeded by ſudden reſt repletion and intemperance, there is no phyſiological ſimilitude. On this ſubject it may be further obſerved, that amongſt men living in the ſame air, on the ſame diet, and with equal temperance; thoſe only, whoſe daily occupation cauſes a compreſſion and concuſſion of the inſpired air, are certainly exempted from the gout.

MI-

MINUTES

OF THE

TWELFTH MEETING,

ON

SATURDAY, April 26, 1794.

Combination of Hydrogen and Oxygen to form Water, and extricate Caloric.

THE Apparatus of Mr. LAVOISIER for this purpofe, is liable to many objections.

It is a work of great danger to exhauft a feven gallon glafs balloon of air; and the exhauftion cannot be compleated, for this experiment, without admitting oxygen gas, and repeating the exhauftion.

The apparatus is complex and expenfive; becaufe it requires two gazometers at leaft, to fupply the Hydrogen and Oxygen gaffes.

Thefe inftruments with their appendages, are too heavy to balance with accuracy; and the extent of water and metal which they

pre-

preſent to the gaſſes, tends to alter the purity and volume of them.

Theſe and other inconveniences are obviated by the inſtrument repreſented in Plate I. fig. 1. The drawing from which this was engraved was ingeniouſly deviſed and ably executed by Sir FRED. EDEN, Baronet. And as it was taken by the ſcale repreſented in this plate, the dimenſions are omitted in the following deſcription.

A B C is a light globular veſſel of flint glaſs, ſhaped in the manner of an adopter, and having the narrow necks A and B oppoſite to each other. The lower part of the adopter is drawn out at C to form the conical tube C *n* D, which is provided with a braſs ſtop cock at the lower extremity. The ſquare mahogany frame F G ſtands parallel with the horizon.

Near the end K L of a long mahogany board, the braſs rod M N is ſcrewed ſo as to ſtand upright. In order to make this rod ſtand firmly, it is provided, near the end M, with a ſhoulder, which meets the braſs plate M O, when the rod is ſcrewed into it; the ſquare braſs plate M O being faſtened at each angle to the board with ſcrew nails.

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In the ſame manner the braſs rod P Q is faſtened at the other end of the mahogany board K L, which end cannot be ſeen in this view of the apparatus. Theſe upright braſs rods ſtanding parellel with each other, paſs through the ſquare mahogany frame F G at H and I; ſo that the frame may be ſlidden upwards or downwards upon the braſs rods.

At each hole in this mahogany frame, through which the upright rod paſſes, a braſs ſocket H *a* is ſcrewed to the lower ſurface of the frame, ſo that the braſs rod may paſs freely through the ſocket and the frame. In order that the frame may be fixed at any elevation, the braſs ſocket is provided with a tranſverſe ſcrew between H and *a*, by which the rod may be preſſed againſt the oppoſite ſide of the ſocket and faſtened to it, ſo as to keep the ſocket and frame in the required poſition. The oppoſite ſide of the frame, near I, is in like manner provided with a ſocket and ſcrew which the preſent view of the inſtrument cannot exhibit.

The veſſel Q containing water, has a tube fixed in the center of its bottom and perpendicular to it. This tube being open at the

M bot-

bottom and closed at the end Q, receives the brass rod I Q and slides on it, so that the water vessel may be sustained at any convenient height. This vessel Q being provided with the stop cock *b*, the water may be made to trickle quickly or slowly from the vessel Q upon a piece of muslin *c c c*, by which it is spreaded over the whole surface of the adopter A B, from which it descends by the tube C D, into the square trough E D, after having served to cool the adopter. *d d d* is a glass funnel cemented into a brass cap at *d f*, from which the transverse tube *f e*, which is provided with a stop cock, may deliver the hydrogen gas of the funnel *d d d* into the adopter A B, through the slender extremity at *e*, which consists of iron, lest it should be melted or closed by the flame of the hydrogen gas. Under the opposite neck of the adopter, stands the funnel *a g g*, intended to receive oxygen gas, and to deliver it by the course *a A h*, into the adopter A B; in order to maintain the combustion of the hydrogen gas. Through a collar of leather fixed in the tube between *i* and A, an iron wire passes bent in the direction *i h e*. The end of this wire at *e*, is distant from the end of

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the tube which ſupplies the hydrogen gas, by 1-8th of an inch, when the wire ſtands in this poſition, to deliver the electrical ſpark and inflame the hydrogen gas the moment it iſſues. The end of the wire at *i*, is ſcrewed into a ſmall braſs ball *i*, by which it receives electrical ſparks from the larger ball *k* of an electrical conductor. As often as the electric matter is made to ſtrike from the ball *k* to the ball *i*, the like ſpark ſtrikes from the end of the wire at *e* to the mouth of the ſlender tube *f e*; and by this ſpark, the hydrogen gas iſſuing in the courſe *d f e* is inflamed inſtantly as it meets the oxygen gas in the adopter at *e*.

The funnel containing oxygen gas, enters water to the depth of three or four inches, in the veſſel R S; the ſize of which admits a pint bottle of gas to be introduced under the funnel and entirely delivered into it through the water. The veſſel T U ſerves in like manner for the ſupply of hydrogen gas to the funnel *d d d*.

When it is intended to accelerate the combuſtion of the gaſſes, nothing more is neceſſary than to keep the hydrogen funnel filled with gas, ſo that it may be preſſed upwards

by a column of three or four inches of water; and at the ſame time to ſupply the oxygen funnel ſo ſlowly, that the water ſhall riſe in it, above the common level, five or ſix inches. In the contrary circumſtances the combuſtion may be retarded at pleaſure: but care muſt be taken all the while, that the hydrogen gas ſhall iſſue in a continued ſtream, and that the flame ſhall be maintained.

As it is neceſſary that the adopter ſhould be firmly ſcrewed to the ſquare mahogany frame, and yet eaſily ſeparable from it, proviſion is made for theſe purpoſes by the following mechaniſm.

Plate I. fig. 2. repreſents this mechaniſm on a larger ſcale. *a b c* is the curve of the neck through which the hydrogen gas is to be introduced into the adopter. The lip at *c* ſtrengthens this mouth of the adopter. *d e* is the external projecting part of the glaſs ſtopper which is accurately ground to ſtop this mouth. This ſtopper being ground to a ſmaller diameter between *e* and *g*, is there cemented into the braſs cap *f g*.

The ſlender tube *h i*, which is to deliver the hydrogen gas, is continued through the glaſs

glaſs ſtopper *d e*, until it communicates by the paſſage in the cock *l* and the cap *k m* with the funnel *m n*.

o p q r repreſents the part of the mahogany frame, in which this neck which is to tranſmit the hydrogen gas, is imbedded midway between *o* and *r*.

The braſs clip *s t* ſhuts upon this neck of the adopter, and preſſes it to the mahogany frame by the ſcrew whoſe head ſpreads to *u*. This braſs clip, at the end fartheſt from *t*, is ſcrewed to the ſquare mahogany frame in the ſame way.

To keep the ſtopper *e d* firm in the neck of the adopter and immoveable, the ſemicircular clip *e d v* embraces the braſs cap *f g* and meets the ſhoulder of the glaſs ſtopper *e d*. From this clip two braſs pins enter the piece *w x y*, which being drawn to the mahogany frame *p q r*, by the ſcrews *z z*, forces the clip *e d v* againſt the glaſs ſtopper *e d*, and thus faſtens this ſtopper firmly in the neck of the adopter.

By the like mechaniſm the oxygenous funnel *a b c*, fig. 3, communicates by a narrow paſſage with the cavity of the adopter *d f g* around the wire *d e*; and this neck of the adopter is faſtened to the frame *h i k*, on

the face *i l* near *i*; whilſt the glaſs ſtopper on this ſide is preſſed and ſcrewed by clips and ſcrews ſimilar to thoſe on the oppoſite ſide of the mahogany frame.

This figure more diſtinctly repreſents the braſs ball *m*, which receives the electrical ſparks and communicates them to the bent wire *m d e*.

It alſo more clearly repreſents the tranſverſe ſcrew at *n*, by which the wire *m d e* may be retained in the required portion.

The wire *m d e* being moveable on its axis *m d*, in a collar of leather well greaſed, the braſs ball *m* is turned round, when the hydrogen gas has been inflamed by the electrical ſparks; and the wire *m d e* turning with the braſs ball *m*, the end *e* of the wire is removed to one ſide and to a diſtance from the flame of the hydrogen gas.

Previous to the uſe of this inſtrument the funnels are to be ſcrewed off; the oxygen funnel at *o p*, fig. 3, the hydrogen funnel at *a b*, fig. 2.

The adopter ſtill carrying its ſtoppers, is to be taken from the mahogany frame, and the hydrogen ſtopper being removed, is to be rinſed with diſtilled water. The hydrogen ſtopper being replaced, the adopter is to drain,

drain, in the poſition repreſented at fig. 1, the ſtop cock of the tube C D being left open. After this time the adopter with its ſtoppers and included air, are to be weighed.

The hydrogen ſtopper being then removed, the adopter is to be filled with diſtilled water at 54.5° and the hydrogen ſtopper is to be replaced, without including any air.

By the weight of the water which thus fills the adopter, its capacity in cubic inches, is to be aſcertained.

The hydrogen ſtopper is now to be taken out and dried, and oxygen gas is to be introduced into the adopter, until the water is totally excluded; the gas in the mean time ſuſtaining the preſſure of a two inch column of water.

An aſſiſtant ſtopping the mouth of the adopter, under the water with his finger, is now to raiſe it up, and preſent it to the experimenter, in the poſition of fig. 1, in order that he may quickly introduce the hydrogen ſtopper.

The gas being retained in a ſtate of compreſſion by the aſſiſtant's finger; and the neck thus ſtopped, being an inch and an half

in length, and only half an inch in the clear diameter, the ſtopper expels its bulk of the gas, when it is introduced; and no air can enter contrary to this current of the gas, provided the ſtopper be inſerted at the inſtant when the aſſiſtant ſlides off his finger.

The adopter now charged with confined oxygen gas is to be faſtened to the frame F G, fig. 1, and the funnels are to be ſcrewed on.

To prevent the hydrogen tube, which enters the adopter, from introducing ſo much as $\frac{1}{100}$ of a grain of atmoſpheric air; oxygen gas is to be ſucked through it, from the ſmaller extremity; and when it is filled with this gas only, the cock is to be ſtopped. The capillary aperture at *h*, fig. 2, is too ſmall to admit any mixture of atmoſpheric air with the gas in this ſlender tube, in the ſhort time allowed for replacing the ſtopper.

The funnel *a g g*, fig. 1, which was lately ſcrewed on, contains air confined by water. This air is to be ſucked away, by means of a ſlender inverted Syphon; and in order that no air may remain in the neck of the funnel, oxygen gas is to be repeatedly introduced and ſucked out. Then it is to be

charged with oxygen gas, and the ſtop-cock is to be opened, to allow a free communication between the gas in the funnel and that of the adopter.

When the water has drained from the internal ſurface of the adopter, for 24 hours, and has gathered in the tube C D, it is to be paſſed off by opening the cock D.

The extremity of this cock, in the mean time, is to touch the ſurface of the water in the veſſel E D, but not to ſink in it. For thus, upon opening this cock, the oxygen gas in the adopter and funnel ſoon accommodates itſelf to the preſent temperature and preſſure of the external air, which are to be noted.

When this is done the cock is to be ſtopped.

The water which confines the oxygen gas in the oxygen funnel will now be found to have preſſed into the funnel to the height of two or three inches and to a level with the water around the funnel.

The capacity of this funnel at different heights being previouſly aſcertained and marked on it, and the quantity of oxygen gas contained in the adopter and funnel being now known;

known; the water around the funnel is to be drawn off, until its ſurface is two or three inches lower than that of the water in the funnel. The purpoſe of this meaſure is, to facilitate the intended entry of hydrogen gas from the hydrogen funnel into the adopter.

The funnel *d d d*, fig. 1, now contains air confined between the water in the veſſel T U and the ſtop-cock above it. This air is to be ſucked out: and hydrogen gas is to be repeatedly introduced and ſucked out, as was done by the oxygen gas of the oppoſite funnel.

Then this hydrogen funnel is to be filled to the lip with meaſured quantities of the hydrogen gas which is to be employed in the experiment; ſo that it may be compreſſed by a column of about four inches of water.

Every thing being now prepared for the entry of the hydrogen gas into the adopter containing oxygen gas; the conductor *m k* is to be charged by an electrical machine which acts vigorouſly. Whilſt ſparks paſs, in quick ſucceſſion, from *k* to *i*, and from the end of the wire *h e*, to the point *e* of the ſlender tube *f e*, the cock between *f* and *e* is to be opened quickly; ſo that the very firſt portion

tion of hydrogen gas iſſuing at *e*, may be inſtantly inflamed.

When the flame appears, the wire *i h e* is to be turned on its axis, until the point *e* is ſufficiently diſtant from the flame.

The combuſtion may at any time be accelerated by increaſing the column of water which preſſes the hydrogen gas; and by leſſening the preſſure on the oxygen gas.

Water is now to trickle from the veſſel Q upon a piece of muſlin *c c c*, which ſpreads it on the adopter. The water which has thus ſerved to keep the adopter cool, trickles into the veſſel which ſtands under it; from which it is to be occaſionally returned into the veſſel Q.

During the conſumption of the gaſſes by the combuſtion, meaſured quantities are to be gradually introduced into the proper funnels; great care being taken all the while that different gaſſes may not be delivered into the ſame funnel; for this would cauſe a dangerous exploſion.

When the proceſs of combuſtion is to be interrupted, the cock which admits the hydrogen gas is to be quickly ſtopped. The flame ceaſing, the veſſels cool; the oxygen gas

gas and aqueous vapour contract their volume; and the water in the oxygen funnel riſes towards the braſs cap *o p*, fig. 3. At this moment, the ſtop-cock of this funnel is to be ſhut, to prevent the water from riſing higher than the cap.

When the proceſs is to be renewed, the oxygen funnel is firſt to be charged with oxygen gas, and the cock is to be opened.

The hydrogen funnel is next to be charged. The wire *i h e* is to be turned to its firſt poſition. Whilſt electrical ſparks paſs quickly from it to the point of the hydrogen tube, the cock of the hydrogen funnel is to be opened; and when the flame appears, the wire *i h e*, fig. 1, is to be turned off as before.

Thus the combuſtion may be carried on for many days; or may be ſtopped and renewed at pleaſure.

In order that the electrical ſparks may ſtrike quickly and vigorouſly, between the wire and the tube at *e*, it is expedient that one end of a ſlender braſs wire ſhould be fixed to the ball or ſcrew of the cuſhion of the electrical machine; and that this wire paſſing under the board K L, ſhould be faſtened, by the

the other end, on the braſs cap *f* of the hydrogen funnel *d d d*.

Since the gaſſes are not to be conſidered as abſolutely free from azotic gas, however nearly they may approach to purity; the quantity of azotic gas collected in the adopter, after the combuſtion has been continued for a long time, will neceſſarily reduce the elaſtic fluid in this veſſel, to the condition of atmoſpheric air. After this time, the flame becomes weaker, and is to be carefully watched; in order that the cock of the hydrogen funnel may be ſtopped before the flame is extinguiſhed. For otherwiſe ſome hydrogen gas will paſs unaltered into the adopter, and will be confounded with the azotic gas, from which it is not eaſily ſeparable.

When the proceſs is terminated, the quantity of hydrogen gas remaining in the proper funnel, is to be determined by the gradations marked on this veſſel; and is to be deducted from the ſum of the meaſures of hydrogen gas employed. This funnel is then to be ſcrewed off. In like manner the gas remaining in the oxygen funnel is to be meaſured, with due attention to the level of the

water,

water, and to the temperature and preſſure of the air at this time. The ſtop-cock being cloſed, this funnel alſo is to be ſcrewed off.

The adopter and the ſtoppers being now in the ſtate in which they were formerly weighed, except that they are charged with the additional weight of the water formed from the gaſſes, are to be weighed again, in the poſition repreſented at fig. 1. The accrued weight is to be noted, but will ſtill be ſubject to the corrections which follow.

To weigh the water thus formed more accurately perhaps, and to examine the quality, it muſt be drawn off from the adopter. For this purpoſe the adopter is to be warmed by wrapping the upper part of it in a hot cloth, after it has drained for 24 hours. A bottle of proper ſize is to receive the extremity of the tube C D, fig. 1; and the ſtop cock of this tube being opened, the expanded gas in the adopter will preſs all the water into the bottle. During the paſſage of the water, the bottle is to be held at ſuch a height, that the orifice of the ſtop-cock may dip only 1-8th of an inch in the water; and when a ſingle bubble of gas from the adopt-

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er, has iſſued through the water, the ſtop-cock is to be inſtantly cloſed.

The gas remaining in the adopter is now to be transferred into another veſſel, in which it may be expoſed, firſt to lime water, ſo that any carbonic acid gas contained in it may be meaſured; and afterwards to ſulphuret of lime, which will imbibe all the oxygen gas, and leave the azotic gas in a ſtate fit for menſuration.

The quantity of heterogeneous matter introduced with the gaſſes during the combuſtion, being thus diſcovered, a proportionate deduction is to be made from the calculated weight of the hydrogen and oxygen gas employed.

In weighing the adopter, after the combuſtion of the gaſſes, it is to be ſuſpected that the gas now contained in it, is chiefly azotic gas; which is lighter than the common air formerly weighed with the ſame inſtrument. Any difference of weight ariſing from this difference of the gaſſes, may eaſily be determined, when the quantity of reſiduary azotic gas has been found in the manner above mentioned.

It is obvious that the weighing, charging, and

and working this apparatus, and the formation of a few drams of water during the combuſtion of the gaſſes; and the ſubſequent menſurations, muſt have employed the experimenter occaſionally, for many weeks; and have afforded the members of this ſociety frequent opportunities of obſerving the phenomena.

But in conformity with a reſolution of the Committee of Publication, which will appear hereafter under its proper date; the neceſſary deſcriptions are compreſſed in theſe minutes of the meeting at which the above apparatus was firſt exhibited for uſe: and by the ſame authority, the experiments for weighing Caloric, are transferred from the original minutes of this and a preceding meeting, to be duly connected with thoſe which were afterwards made on the ſame ſubject.

During the firſt hour, of the combuſtion in this inſtrument, about five pints of hydrogen gas were conſumed. The flame was very bright, but ſcarcely 1-8th of an inch in length by 1-16th in diameter. It afterwards gradually increaſed to the length of 3-8ths of an inch, during the combuſtion of the firſt

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twenty-five pints of Hydrogen gas. For the orifice of the capillary tube became wider when the narrower extremity was burnt by the flame. But when the orifice became blunted and coated with oxyd of iron, no further enlargement of it took place.

It was obferved by Mr. FORSTER and other members that the flame was bent towards the hydrogen funnel about ten degrees from the perpendicular line in which the tube delivered the gas. This was at firft imputed to fome change of figure produced at the orifice by the flame which heated it to rednefs: but it was foon after found to be owing to the current of oxygen gas towards the flame.

The combuftion was carried on for about two hours at a time, on different days, until the column of water in the tube of the adopter was 8½ inches in length.

At each of thefe times the temperature of the gaffes and the height of the barometer were carefully noted.

In the manner defcribed by LAVOISIER with great perfpicuity, the volume of each gas at 29.85 inches of the barometer, and 54.5° of the thermometer was afcertained;

and the weight of the oxygen gas confumed was found to be 416.5 grains, and that of the hydrogen gas 72.5 grains; the weight of both being 489 gr. = 1 oz. 11 dt. 9 gr.

The water produced from thefe gaffes weighed 487 grains = 1 oz. 11 dt. 7 gr.; and contrary to all expectation, had no fenfible acidity.

The combuftion of the hydrogen gas during the laft minute, appeared as vivid as at any former period; and did not denote any confiderable azotic impurity of the gas. From this circumftance and the tafte of the water, it was inferred that the gaffes employed were uncommonly pure; and that many ounces of water might be thus compofed in this fmall inftrument, before the azotic gas fhould predominate fufficiently to ftop the combuftion.

The refiduary oxygen gas in the adopter, is ftill preferved for future examination of its purity.

In this firft experiment nothing was done to abftract the moifture of the gaffes, becaufe the weight was to be taken in the prefent ftate of them; and the aqueous matter conveyed in the gaffes might eafily be afcertained

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afterwards by the accurate methods of Mr. De Luc and Mr. Saussure.

It is much to be doubted whether a gas passing in a continued current, from Lavoisier's gazometer charged with water, through coarse powder of caustic vegetable alkali, for many hours or days, can all be equally dry, so that the weight of the whole may be truly calculated from that of the small quantity which can be accurately weighed at once.

The experiments of Mr. Cavendish, who is the original author of this most important discovery of the composition of water; and those of Mr. Lavoisier, Mr. Meusnier, and some others, all agree with the foregoing, in shewing that water is a compound formed of hydrogen and oxygen, nearly in the proportion of 15 to 85.

The quantity of Caloric emitted from the gasses, during the union of their bases, in this combustion, is much greater than that extricated in the combustion of any other bodies of equal weight; when measured by the Calorimeter. But the quantity propelled in Light, remains incalculable.

This composition of water has been strongly controverted by Dr. Priestly and other philosophers, who have been misled chiefly

by the uſe of impure gaſſes. For azotic gas expoſed to the flame in this experiment, enters into a ſpecies of combuſtion with the oxygen gas, and the baſes unite to form nitrous acid. This alſo is one of the ſtriking diſcoveries of Mr. CAVENDISH; to which may be added, that the union is promoted by the preſence of a ſmall quantity of carbonic acid gas.

The French Academicians obſerved that the quantity of acid in the water formed from their gaſſes, was leſs in proportion to the purity of them. And the experiment of this Society ſhews that an ounce of water may be compoſed, before the very ſmall quantity of azotic gas diffuſed in ſo much oxygen gas, can be compelled by the flame into the condition neceſſary towards the union of it with oxygen.

The oxygen gas uſed in this experiment was drawn from nitrous oxyd of mercury, in the manner formerly deſcribed in theſe minutes. The precautions uſed in preparation of the hydrogen gas; and the proceſſes for the decompoſition of water, were announced for ſubſequent meetings.

MINUTES

OF THE

THIRTEENTH MEETING,

ON

SATURDAY, May 3, 1794.

Description and Use of a new Instrument for Respiration.

Attempts to weigh Caloric.

THE improved Apparatus proposed at the eleventh meeting, for the purpose of truly measuring the carbonic acid gas and the water produced in the respiration of air or oxygen gas, consists of the following parts.

Plate II. fig. 2, represents the bell-glass and transverse tube described in the minutes of the ninth meeting. A section of this tube is represented in fig. 4, to shew that the diameter of the bore is the same in every part,

 left

left any water ſhould lodge in it to produce a rattling and unequal reſpiration.

a b c d, fig. 5, repreſents a cylindrical veſſel made of the thinneſt tinned iron, and placed on the perforated ſtool, A B C. Within this veſſel, another is fixed, which has the ſhape of the bell-glaſs above mentioned, but it is ſo much ſmaller as to enter it freely. The upper rounded part of this interior veſſel appears at *e g*; and its ſides below *e g* being parallel with the ſides *a b* and *d c* of the exterior veſſel, the diſtance between them is about a quarter of an inch.

The lip of the interior veſſel is ſet off all around at a right angle with the ſide, to meet the exterior veſſel at *b c*, where it is ſoldered to it, and ſerves as the bottom of the compartment formed between the exterior veſſel and the interior.

In the ſection, fig. 6, this compartment is ſhewn. *a b c d* repreſents the exterior veſſel, *e b c g* the interior, *a b e* and *g c d* the compartment between them, and *b* and *c* repreſent the cloſure or bottom of the compartment, in which the bell-glaſs fig. 2 may enter and move freely upwards and downwards.

In the center of the rounded top of the interior veſſel *e g*, fig. 5, the ſlender tube *h i* is ſoldered. The diameter of this tube, being a quarter of an inch, the end *h* enters the neck of the bell-glaſs when it ſtands in the compartment above deſcribed, and the end *i* of the ſlender tube is cemented into the braſs cap *i* which ſcrews to the ſtop-cock *i k*.

The ſmall bell-glaſs *k l m* whoſe neck is cemented into the braſs cap *k*, ſcrews to the ſtop-cock *i k*. All this is more diſtinctly ſeen in the ſection, fig. 6, which ſhews the tranſverſe ſtay *b c*, by which the poſition of the tube is ſecured in the center of the ſpace *b c g c*.

D E F, fig. 5, is a veſſel containing water to the height *n*, but which may be filled to the height *k*.

When the ſtop-cock *i k* is opened, any gas introduced into the ſmall bell-glaſs at *l m* is forced by the water through the tube *i h*.

D E F is repreſented in this figure as a tranſparent veſſel, to ſhew the ſmall bell-glaſs *k l m*. But for uſe, a tin trough rounded at the ends, is more convenient. The width of this trough is ſufficient to ad-

mit the ſmall bell-glaſs at one end: the length affords a full view of the bell-glaſs to the aſſiſtant who is to ſupply it, and alſo gives ſufficient ſpace for the introduction of ſucceſſive pint meaſures of the gas, through the water, into this ſmall bell-glaſs.

This trough is alſo conſiderably deeper than the veſſel D E F fig. 6, in order that a pint bottle may more eaſily be introduced and emptied of its gas under the bell-glaſs *k l m*, fig. 6, and that a longer bell-glaſs than *k l m* may be occaſionally uſed, from which the gas may be preſſed up by the weight of a ten inch column of water in the veſſel D E F.

When the bell-glaſs for reſpiration, fig. 2, ſtands in the deſcribed compartment of fig. 5, the mouth *b c*, fig. 2, coincides with the bottom *b c*, fig. 5; the neck *a d*, fig. 2, receives the tube *h*, fig. 5, and the ſhoulder of the bell-glaſs, fig. 2, reſts on *e g*, fig. 5. The ſtop-cock of fig. 2 being open, and ſixteen ounces of lime water poured into the compartment in which the large bell-glaſs fig. 2, ſtands, the water will riſe high enough in the narrow compartment to exclude the air from the bell-glaſs, through its tranſverſe tube.

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Whatever air may remain near *a d*, fig. 2, is to be expelled by introducing at *l m*, fig. 5, ſucceſſive portions of the gas which is to be breathed, and paſſing them off through the tube *a g k*, fig. 2, whilſt the bell-glaſs for reſpiration is moved a little up and down. The cock of the large bell-glaſs is then to be cloſed.

If the inſtrument be well made, no more than half a cubic inch of air or gas will remain between the top of the bell-glaſs and the ſtop-cock. But this quantity is neceſſary to prevent the water in the compartment from riſing above the orifice *h* of the tube *i h*, fig. 5, and flowing into the ſmall bell-glaſs *k l m*.

In this ſtate of the veſſels the ſmall bell-glaſs *k l m* is filled with water to *k*. The tube from *k* to *h* is filled with the oxygen gas or air employed, and about half a cubic inch of the ſame air ſtands around the tube near *h*.

The ſtop-cock at *i k* is now to be ſhut, and the ſmall bell-glaſs *k l m* being ſcrewed off to leſſen the weight, the veſſel *a b c d*, with the tube and ſtop-cock *h i k*, and the veſſel, fig. 2, ſtanding in the compartment of fig. 5,

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together with the 16 ounces of lime water contained in this compartment, are to be weighed in a balance which will ſhew the preponderance of half a grain at either arm ſuſtaining 41760 grains, which is the weight of the veſſels and lime water.

The apparatus thus weighed is to be replaced on the ſtool A B C, fig. 5; the ſmall bell-glaſs *k l m*, being ſunk in the water to *k*, is to be ſcrewed on to the cock *i k*; and the gas intended for reſpiration being introduced at *l m*, will raiſe the large bell-glaſs, fig. 2, in proportion to the quantity introduced.

For general uſe no more than one half of the bell-glaſs is to be filled with the gas; and in proportion to the conſumption of it by reſpiration, more is to be added by an aſſiſtant.

When the experiment is to be made with pure oxygen gas, and the intended quantity has been introduced, the Experimenter is to continue his reſpiration, cautiouſly towards the end, until the bell-glaſs for reſpiration is quite ſunk in the compartment above deſcribed, and until the aſſiſtant has informed him that the water in the ſmall bell-glaſs, fig. 5, has riſen to its firſt height at *k*.

At

At this moment the Experimenter is to ſtop the orifice of the mouth-piece at *k*, fig. 2, with his tongue, until he has ſtopped the cock *g*.

The bulk of the gas now remaining near *a d g*, fig. 2, will be equal to that which ſubſiſted there at the commencement of the reſpiration; and the difference of their weights will be too ſmall to be regarded in the reſpiration of 100 or 200 pints of oxygen gas.

If oxygen gas mixed with the azotic be uſed for reſpiration, the Experimenter is to weigh the veſſels in the manner deſcribed, after the azotic gas has been introduced; and he is to reſpire the oxygen gas introduced afterwards as long as he can.

In either caſe, when the reſpiration ceaſes, the Experimenter is to ſtop the orifice of the mouth-piece with his tongue until he ſtops the cock *g h*, fig. 2: then ſtopping the cock *i k*, fig. 5, he is to ſcrew off the ſmall bell-glaſs *k l m*, and to weigh the veſſels and contained lime water as at firſt.

In either caſe alſo the encreaſed weight of the lime water will ſhew the quantity of water and carbonic gas of the reſpiration.

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But as the lime water loſes ſomething by evaporation during the experiment, this loſs is to be aſcertained by expoſing it under the ſame circumſtances of motion, preſſure, temperature and time, without reſpiration.

By depreſſing or elevating the large bell-glaſs during the reſpiration, the preſſure of a ſix or ſeven inch column of lime water, or cauſtic vegetable alkali, may be added to that of the atmoſphere, or taken from it. The preſſure is added when the water in the compartment of the veſſel, fig. 5, is made to ſtand ſix or ſeven inches above the ſurface of that in the large bell-glaſs; and the preſſure is as much diminiſhed when the water in this bell-glaſs is made to ſtand ſo much higher than that on the outſide of it.

As the inſtrument is capable of producing ſo great an elevation and depreſſion of the lime water in the large bell-glaſs, by the mere elevation and depreſſion of this veſſel; no other contrivance is neceſſary for accelerating the abſorption of the carbonic acid gas of moderate reſpiration. For by this motion, freſh and extenſive ſurfaces of the lime water may be continually expoſed to the reſpired gas, on

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the inſide of the bell-glaſs, and the outſide of the veſſel *e g*, fig. 5, which the bell-glaſs embraces.

In the firſt ſeries of experiments to be made with this apparatus, a quart of azotic gas is to be introduced with a pint or more of oxygen gas, and during the reſpiration, oxygen gas is to be ſupplied until the whole of it amounts to one or two hundred pints; a proper quantity of fine lime being in the mean time mixed with the lime water. When the Experimenter has reſpired the laſt portions of the oxygen gas as long as poſſible, the remaining gas, which will be chiefly azotic, is to be transferred into another veſſel, after the weight has been taken, in the manner above mentioned; and then the quantity of pure azotic gas is to be aſcertained by withdrawing from it whatever oxygen gas remained in it.

If the bulk of the azotic gas, when duly meaſured, ſhould be found to remain unaltered, the preſent notions of the paſſive character of this gas in reſpiration, will be better eſtabliſhed. If the bulk ſhould be leſſened, it will appear that a certain quantity of this gas enters the blood or is otherwiſe expended along with the meaſured quantity of oxygen

gas.

gas. If the bulk ſhould be encreaſed, it will be inferred that the added quantity exhales from the lungs during the conſumption of the known quantity of oxygen gas.

This experiment is to be repeated, under the greateſt and ſmalleſt preſſure of the reſpired gaſſes, which the inſtrument can be made to produce; in order to determine whether azotic gas is forced into the blood by ſuch preſſure, or emitted from the lungs in the contrary circumſtance; and whether the quantity of carbonic acid gas of reſpiration varies with the preſſure; the quantity of oxygen gas reſpired being the ſame. If it ſhould be found conſiderably greater, under the ſmaller preſſure of the oxygen gas in reſpiration, than under the greater preſſure, it may be inferred that ſome carbonic acid gas tranſpires from the vaſcular ſyſtem of the lungs.

In another ſeries of experiments, oxygenous gas only is to be breathed until one or two thouſand grains of it have been conſumed under the mean preſſure. Then the encreaſed weight of the lime water will ſhew how much has been expended in the formation of carbonic acid gas and water, or how much

much has paſſed into the ſyſtem, or has been exhaled from the lungs.

The relative quantities of carbonic acid gas and water of reſpiration, are to be determined by detaching the former from the Carbonat of Lime, and meaſuring it accurately in the manner of LAVOISIER.

The like experiment is to be repeated, with augmented preſſure of the reſpired gas; and alſo with diminiſhed preſſure.

Theſe will undoubtedly ſuggeſt other trials, until the medicinal as well as the general theory of reſpiration ſhall be eſtabliſhed on a firm baſis.

It is now to be obſerved that the intended menſurations will be liable to objections, if the ſtop-cock *i k*, fig. 5, be not properly managed.

When the oxygen gas is conſumed very quickly, by the quick and full reſpiration and compreſſion of it, and it is as quickly ſupplied in a continued current through the tube *i h*, fig. 5, the ſtop-cock *i k* may be open. But in the contrary circumſtances it ought to be ſhut ſo far as to admit the ſupply of gas into the large bell-glaſs with an uninterrupted current, and the full preſſure

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of a column of water of about ſeven inches, preſſing upwards from *l* to *k*, fig. 6. For otherwiſe the reſpiration will communicate with the gas in the ſmall bell-glaſs *k l m*, fig. 6, ſo that a part of the carbonic acid gas and water of reſpiration may be depoſited in the ſmall bell-glaſs *k l m*, fig. 6, inſtead of being retained in the lime water or other liquor intended to receive them.

An inſtrument of this kind or a little taller, will be found the lighteſt and moſt convenient that can eaſily be deviſed, for the reſpiration of hundreds of pints of oxygen gas, with a view to the medicinal effects.

Whilſt thirteen pints of hydrogen gas were burning briſkly in the apparatus lately deſcribed, and a continued ſtream of water was required to keep the upper part of the adopter cool; the experimenter ſhewed the beſt method of procuring this gas, during the ſolution of iron in diluted ſulphuric acid; and in the mean time related the experimental proofs

proofs of this gas being produced from the water, and not from the acid or iron: a part of the water being decomposed by co-operating powers; namely the attraction of the sulphurous and metallic principles of the nascent salt, tending to draw to them more oxygen than the acid can furnish; and the attraction of the hydrogen to caloric which wafts it away.

Twenty pounds of sulphuric acid of the manufacturers, were exposed to the greatest heat it could sustain without boiling, for forty-eight hours, in a retort of flint glass, covered from the light, but admitting air.

It was observed that green glass was unfit for this business, being apt to crack in the midst of the process; and that even a flint glass retort will crack, if the sand rise around it higher than the evaporable charge, and expose it thus overheated, to the colder liquor which trickles from the helm. The vessel in which the distilled odorous acid was received, did not touch the neck of the retort, but allowed the oxygen of the air to enter; and under the like exposure, the concentrated acid was permitted to cool slowly for two days; after which it was poured from the deposite of vitriolated Kali, and diluted with an equal weight of water.

For the intended ſolution, ſmall iron nails were preferred; for the purity which the metal acquires by the repeated heating and hammering; and for the extent of ſurface which they preſent to a weak acid.

They were cleanſed by agitating them in hot water, to which the diluted ſulphuric acid was gradually added, until the liquor began to ſcale them. After a few minutes they were ſcaled to brightneſs, and carefully rinced in hot water. Being introduced into a pint bottle to fill three-fourths of it, water lately diſtilled and heated to 100°. was poured on them, until it roſe almoſt to cover them.

The diluted ſulphuric acid was then added gradually, until a briſk effervеſcence aroſe. The hydrogen gas thus produced, was directed by a bent tube inſerted in the bottle, through water into a veſſel ſtanding inverted on the funnelled ſhelf of a ſmall trough. As the air left in the upper part of the bottle, at the commencement of the ſolution, paſſed off but partially with the firſt portions of hydrogen gas; it was deemed neceſſary that the iſſuing gas ſhould paſs off to waſte, to the amount of ten times the bulk of the air; before the ſubſequent portions of hydrogen gas ſhould be conſidered as pure and fit for uſe.

The temperature of the effervefcing charge was kept up to 100° or more, by placing the bottle in warm water, in order that the weakened acid might act more brifkly, and that no faline cruft fhould form upon the nails.

Each bottle intended to receive the pure hydrogen gas, was new and referved for this ufe only; and was filled with water for a few minutes, and then moved fo as to detach any fmall bubbles of air which might have clung at the fides or fhoulder, before it was inverted on the fhelf through which the gas iffued.

The temperature of the place being kept at 54° each bottle, when flowly filled with gas, in the courfe of five minutes or more, under the preffure of a column of water of two inches, in addition to that of the air, was held perpendicularly by the hand previoufly wetted and cooled in water, whilft the ftopper was quickly flidden into it; to keep the gas in a ftate of compreffion. The bottles thus filled fucceffively, were arranged in a veffel containing as much water as ferved to cover the ftoppers and mouths, which were inverted in it.

When the hydrogen gas iſſued very ſlowly, the bent tube was taken out of the bottle containing the nails, and its mouth was as quickly ſtopped with the finger, until a freſh charge of the diluted ſulphuric acid was introduced, in quantity ſufficient for the renewal of the efferveſcence. This being quickly done, whilſt hydrogen gas was iſſuing from the bottle, little or no air entered; and therefore but little of the hydrogen gas now produced, was paſſed off to waſte.

It was with a view to this additional charge of acid, that the length of the bottle was twice greater than the diameter of it; and that the neck was an inch in length by only 3-8ths of an inch in the diameter of the aperture. For through a wider and ſhorter neck, the efflux of gas is weaker, and the heavier air is apt to preſs into the hydrogen gas remaining in the bottle. The aperture of the bent tube was only 1-16th of an inch in diameter: becauſe hydrogen gas iſſuing in ſmall bubbles through a column of cold water, ſooner arrives at the required temperature and depoſites its moiſture, than in the contrary circumſtances.

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The trough used for this purpose, contained only three quarts of distilled water; which were sufficient to cover the shelf, and to exclude the air from any number of pint bottles successively applied, in order to be filled with the hydrogen gas. Thus the impurities of great quantities of water were avoided.

When the charge of acid and iron was exhausted of the gas; the martial solution was immediately poured off, and the nails were repeatedly rinced with hot water, which was poured off from them by inverting the bottle and sustaining the nails with the finger. The process was afterwards renewed in the foregoing manner.

The experiment proposed by Dr. LATHAM as an attempt to weigh Caloric, was commenced in the presence of Dr. LATHAM, Dr. POWEL, Mr. YOUNG, Mr. GRUBB, Mr. TAYLOR, and Mr. DE GRAVE an eminent Artist who made the balance and weights, and assisted in applying them to this use. It was a erwards prosecuted at different times in the presence of all the members,

As Dr. Latham perceived, before any confiderable advances were made in this bufinefs, that there was no probability of fuccefs, the following particulars only appear in the minutes.

A thin matrafs the body of which was $9\frac{1}{2}$ inches in diameter, the neck which tapered a little, fix inches in length, and the mouth half an inch in diameter; was charged almoft to the neck, with the folution of vitriolated natron mentioned in the minutes of the fifth meeting; the temperature of the folution being 90°.

A fmaller glafs matrafs, including five pints of air, was cemented by its neck, into the mouth of the larger. The weight of thefe veffels, with that of the cement, and of the brafs wire by which they were to be flung to the beam of the balance, was twenty ounces: the weight of the faline liquor was 272 oz. 8 dt. 23 grs. the weight of all was 292 : 8 : 23, at the common temperature of 53°, when the barometer ftood at 29.1 inches.

As a confiderable quantity of falt had cryftallized, during the cooling of the folution, in thefe circumftances, from 90° to 53°; the

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matrafs containing the liquor was heated to 140°, and was agitated in the mean time, to promote the folution of the falt. The veffels were flung as before on the arm of the balance, when the temperature of the air was 53°, and that of the folution 140°, and now weighed 292 oz. 9 dt. 13 grs. The apparent weight of the hot veffels being greater by fourteen grains than that of the cold veffels.

By fubfequent obfervations it appeared, that as the veffels cooled to the common temperature of 53°, the apparent weight was gradually leffened, although the barometer was ftationary; and that when they were included in a cylindrical veffel clofed at the bottom, to leffen the effect afcribed to the afcending current of air around hot bodies, their apparent weight was ftill greater as they were hotter; by reafon of the dilatation of the air around them, and the confequent diminution of its denfity and buoyancy; and alfo in confequence of the elongation of that arm of the balance under which the hot veffels were fufpended.

When the faline liquor had cooled towards 55°, and began to fhew fmall capillary cryftals; the barometer being at the former

height and the temperature of the place 53°; the weight of the ſolution, veſſels and ſling, was leſs by a grain only, than that formerly taken when they were colder. The cryſtals encreaſed rapidly in number and ſize, from the moment of the firſt appearance, until they extended through the whole of the liquor.

The temperature in the mean time aroſe gradually to above 70°. notwithſtanding the waſte of Caloric by diffuſion to the air.

As the temperature encreaſed by the cryſtallization, the apparent weight increaſed for the reaſon above mentioned; but when the veſſels had cooled to 53°, which was the common temperature of the place, they appeared to have the ſame weight as at firſt; namely 292 oz. 8 dt. 23 grs; the barometer having remained ſtationary all the while.

The dilatation of the air in the cylindrical veſſel in which the matraſſes were ſlung and weighed; and the effect of this dilatation, on the apparent weight of the veſſels, being duly conſidered; it appeared that ſome other cauſe concurred to make the veſſels weigh more when hot, than in their cold ſtate: and it was ſoon obſerved that the elongation of the

the arm of the balance, which was moſt affected by the hot veſſels, was the cauſe. For when the balance, thus charged, was perfectly even, any warm body, or even the Experimenter's hand, cauſed that arm towards which it was approached, to preponderate; $\frac{1}{28000}$ of the weight ſuſpended at either arm, being ſufficient to move the index to either ſide, as the balance had never been uſed for any other purpoſe, ſince the adjuſtment of it by the maker.

Upon the whole it appeared that the quantity of Caloric extricated during the cryſtallization of ſo much Glauber's ſalt, did not amount to half a grain, although Caloric ſhould gravitate; and that very ſmall variations in the denſity of the air, whether from temperature or preſſure, were ſufficient to defeat the purpoſes of the experiment.

In conſequence of ſome remarks made by Dr. LATHAM, Mr. HYATT, and Sir FREDERICK EDEN; the matraſs containing the cryſtals and mother liquor of the Natron vitriolatum thus confined, was heated again until the ſalt was diſſolved; in order to renew ſome phenomena which were but ſlightly noticed before.

To effect this ſolution, the charged matraſs was placed in warm brine of ſea ſalt, which was quickly heated in hot ſand to 170°. The matraſs being frequently agitated to promote the ſolution, was found, at every removal of it from the hot brine, to have little more than the common temperature of the air of the place, until the greater part of the ſalt had been diſſolved; which did not happen before the expiration of 15 minutes, from the time when the temperature of the hot brine was 170°.

Thus it appeared that almoſt all the Caloric received by the contents of the matraſs, during 15 minutes, from the brine continually heated to 170°, was expended in the liquefaction of the ſalt; and was ſo far engaged around the ſeparated ſaline particles, as to become inſenſible to the thermometer.

After the greater part of the ſalt had been diſſolved, the temperature of the ſolution increaſed quickly to equal that of the brine in which it ſtood, and to keep pace with it until both were heated to 212°. All this while the ſolution of Vit. Natron increaſed gradually in bulk, and roſe in the ſlender neck of the matraſs; and in cooling afterwards, it ſhrunk gradually,

gradually, in the manner of a cooling thermometer, until it arrived at the temperature of about 55° or 56°, at which the cryſtallization commenced again.

At this moment the ſpontaneous incaleſcence by cryſtallization recommenced; and as it advanced, the volume of the ſaline maſs increaſed; partly by reaſon of the incaleſcence; but chiefly from another cauſe. For when the cryſtallization was compleated, and the whole had cooled to about 55° degrees; the volume was greater by about 1½ cubic inch, than it was at the ſame temperature previous to the cryſtallization.

As the central parts of the liquor were the lateſt in cryſtallizing, the cryſtals which ſhot from thence upwards, puſhed forth more than a quarter of an inch above the mother liquor.

All this ſhewed the cloſe analogy between cryſtallization and freezing; and between ſolution and thawing. "And the like analogy "appears in many other ſaline liquors."

When the ſame matraſs was filled to the middle of the neck, partly by the ſalt which had cryſtallized in it, and partly by the mother liquor; and was ſuddenly plunged in water

water heated to 140°, the liquor ſunk almoſt two inches, in the neck, and continued at this ſtation for ſeveral minutes: the Caloric which expanded the veſſel and increaſed the capacity of it, being expended in the liquefaction of the ſalt, without augmenting the temperature conſiderably.

It was obſerved of theſe menſurations of the temperatures of the liquors incloſed in cemented veſſels, that they were generally approximations to the true temperatures; as the thermometers were applied only on the outſide of the veſſel and covered with a woolen cloth.

During this experiment of Dr. LATHAM, the experimenter thought of the following, and ſoon afterwards provided the inſtruments for it; hoping that the Caloric eſcaping from lime and water in the proceſs of ſlaking, might leave them ſenſibly diminiſhed in weight.

Glaſs matraſſes, like thoſe uſed in the foregoing experiment, were employed at firſt; but

but ſo many failures happened from the unequal ſwelling of the lime in flaking, or from the caſual trickling of the water between the veſſel and the lime, in which caſe the veſſel always cracked in the line in which it was thus partially heated, that the experimenter was obliged to have recourſe to a metallic veſſel.

A thin veſſel of tinned iron, having a ſmall neck like that of a matraſs, but fitter to receive the mouth of a glaſs matraſs, was provided. This veſſel was charged with 196 ounces of Lime broken to fragments of about half an inch in diameter, and freed from the powder, to give a free paſſage to the water.

A cork notched at the ſides lengthwiſe, and covered with muſlin, was fixed in the mouth of the matraſs, after it was charged with 196 ounces of water. This quantity being found neceſſary for flaking the Lime, even in cloſed veſſels which condenſed the vapour into water, and returned it into the Lime.

The neck of the matraſs being inclined to one ſide and heated, was waxed and fixed into that of the metallic veſſel, ſo that the juncture was firm and perfectly air-tight.

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The bottom of this laſt was then turned upwards and ſlung to the arm of the balance.

	oz.	dt.	gr.
The Lime weighed	196	0	
The water - - -	196	0	
The veſſels, wax and ſling	80	5	
The whole weighing	472	5	=226680

The barometer ſtanding at 30 inches; the thermometer at 54.3°.

When the air was quieſcent, and the experimenter ſtood at a proper diſtance, a grain weight was ſufficient to caſt the balance either way.

The veſſels were now turned and ſlung, with the bottom of the matraſs upwards. The water trickled ſlowly through the muſlin and the notches in the cork, until the air in the lower veſſel became dilated by the ſlaking lime, and preſſed upwards through the muſlin, or againſt it, ſo as to ſtop the deſcent of the water. When the air in the lower veſſel had cooled, the water deſcended again; and this deſcent was occaſionally accelerated by applying a hot cloth on the bottom of the glaſs veſſel.

No more than an ounce of water could be preſſed

preſſed at once into the Lime, without endangering the ſolder of the tinned veſſel ; and four days were therefore expended in ſlaking the Lime.

After the ſlaked Lime had cooled for forty-eight hours, the apparent weight of the veſſels with their contents was noted in a regiſter, as often as it was found to be varied with the ſtate of the barometer and thermometer, which were placed at the fulcrum of the balance, during the courſe of a month.

As the regiſter only ſhewed how the apparent weight increaſed and diminiſhed with the falling and riſing of the mercury in the barometer, at equal temperatures; and how it encreaſed or decreaſed directly with the temperature, at equal heights of the barometer; the inſertion of it in this publication is unneceſſary.

It happened unfortunately, during this month and a longer time, that the barometer and thermometer never coincided at the preciſe points at which they ſtood, at the commencement of the experiment. It was only on the 22d day that they approached ſo nearly that, by a computation founded on the regiſter, it ſeemed there was a loſs of the ori-

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ginal weight, amounting to more than a grain; and probably in consequence of the escape of Caloric during the flaking: the utmost care being taken that no dust should affect the instruments; and there being greater reason to suspect that the new metallic vessel had increased in weight by tarnishing, than that it had decreased by the touch of a silk handkerchief with which it was wiped two or three times.

When this experiment was devised, the chances against the expected coincidence of the barometer and thermometer, at the points first observed, were not sufficiently considered. But Lord STANHOPE soon suggested the necessary improvement; and it was resolved that in a future experiment, the balancing weights should be included in a vessel of the same figure and dimensions precisely with those of the Lime and water, and that the former as well as the latter should be perfectly closed.

Under these circumstances, the vessels on both sides of the balance will be equally affected by the variations in the pressure and temperature of the air in which they are to be weighed, and the true weight will appear at all times.

MI-

MINUTES

OF THE

FOURTEENTH MEETING,

ON

SATURDAY, May 10, 1794.

Menſurations of Caloric.

Oxydation of Metals.

THE Society being deſirous to ſee the experiments of modern philoſophers, for meaſuring temperatures and the Caloric of bodies, theſe ſubjects were introduced in the didactic order: and the experiments deſcribed by Dr. CRAWFORD from the 1ſt to the 29th page were exhibited. Sir JOHN INGLEBY, Meſſrs. JOHNSON, YOUNG, TAYLOR, and CREVEL aſſiſted; and after the reference to Dr. CRAWFORD, no minutes of the particulars were deemed neceſſary, in this ſtage of the buſineſs.

P In

In the ordinary proceſſes for the calcination of metals, by expoſing them to the joint action of air and fire; the calces or oxyds are formed by the union of the oxygen of air with the metallic body.

Each oxyd exceeds its metal in weight, in proportion to the quantity of oxygen combined; and the metallic appearance is altered more or leſs, in proportion to the quantity of oxygen which the oxyd has received.

In theſe proceſſes, the oxydation of each metal takes place only at the ſurface expoſed to air; and it is neceſſary to rake off the oxydated pellicle, to give the air free acceſs to the clean ſurface of the metal, before the whole of it can be oxydated.

In the pellicles which are quickly removed, the metal ſubſiſts in the firſt degree of oxydation. The cupreous oxyd for inſtance is brittle and deprived of metallic luſtre, but ſtill has a colour inclining to that of copper. The martial oxyd ſo formed, approaches in colour to that of iron, and is ſtill magnetic; the oxyds of lead and tin are grey.

When ſuch oxyds are longer and more advan-

vantageoufly expofed to air and fire, they encreafe in weight; and lofe the metallic appearance entirely. The metals which receive the fmalleft augmentations of weight during the compleat oxydation, in this manner, hold 14 parts of oxygen combined with 100 of the metal. Tin and probably Zinc hold 25; and intermediate quantities of oxygen are held in the oxyds of other metals.

This was fhewn in refpect to mercury and iron, at the fixth and feventh meetings; and the oxydations of Tin and Lead were now exhibited, in the reverberatory furnace.

When the pellicles were quickly raked off, the combuftion of them was manifeft; and on the grounds formerly mentioned, as well as the undoubted combuftions of Zinc, Arfenic, Iron and Antimony, it was inferred, that every calcination of a metal is a fpecies of combuftion.

On this occafion it was obferved that fome metals, fuch as Lead, became oxydated much fooner in the common reverberatory furnace, than in a muffle; and fooner when the flame beats on them, than when pure oxygen gas and fire only act on them: becaufe fuch oxyds

are difpofed to imbibe carbonic acid, and are the more quickly formed in the circumftances in which this acid is prefented to them.

It was reprefented that the flow progrefs of the oxydation of fome of the metals, was owing to the pellicle of oxyd which forms on them. For in all metals, which by their volatility break the pellicle and expofe themfelves more fully to air, the oxydation is quick and the combuftion manifeft; and metals which, in the ordinary proceffes for calcination, fhew no vifible figns of combuftion, burn rapidly when divided and heated with nitre, which fupplies oxygen by its acid, and alkali to cleanfe the furfaces.

The foregoing impediments, which prevent the combuftion which takes places in every calcination, from being vifible in fome, were fhewn in an experiment made with Zinc in an open crucible.

Four ounces of Zinc were flowly heated to the degree neceffary for fufion: the greater heat in which it may be evaporated, being cautioufly avoided. The experiment fhewed that, in fuch circumftances, the Zinc contracts a pellicle, but cannot enter into the ftate of vifible combuftion.

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The Zinc was then further heated and removed from the fire, without any visible combustion. But when the pellicle was broken, it catched fire, although it had cooled a little; and burned quickly with vivid illumination, until it formed the white oxyd commonly known by the name of Flowers of Zinc.

To shew what passes in the oxydation of Zinc, in a more satisfactory manner, and at the same time to remove the doubts which a member had expressed in regard to the possibility of inflaming and oxydating this metal in pure oxygen gas; the following experiment was made.

Two ounces of Zinc were placed in a porcelain retort joined by an intermediate stop-cock to a bent funnel similar to that used at the sixth meeting, for the oxydation of Mercury. The funnel and retort were filled with pure oxygen gas confined at the mouth of the funnel by water; and the management of the experiment was entirely committed to Mr. Young, who shewed great attention to it.

When the fire applied to the retort was sufficient to melt and sublime the Zinc; it

was announced by Mr. Young, and obſerved by ſeveral members, that a white vapour deſcended in a column from the retort and through the oxygen gas in the funnel. The volume of this laſt was ſoon augmented ſo much that bubbles iſſued from time to time from under the funnel through the water in which it was immerſed.

With the curioſity and zeal of a philoſopher, Mr. Young applied a lighted taper to the bubbles of elaſtic fluid which thus eſcaped; and it was obſerved by all who were as attentive as himſelf, that the bubbles catched fire, and exploded, like a mixture of hydrogen and oxygen gaſſes.

The experimenter who was employed at a diſtance, heard a ſmall exploſion of this kind, and gave a caution concerning it. The match was however applied again; and the flame communicating by the bubbles to the contents of the funnel, the whole exploded with a loud report, and blew the funnel to pieces.

Mr. Young ſoon afterwards preſented a drawing of an inſtrument in which he wiſhed the experiment to be repeated.

It repreſented a long glaſs tube, joined at each end, by an intermediate ſtop-cock, to a bent

bent funnel of glaſs. The Zinc was to be placed in the middle of the tube, and there expoſed to the fire of a ſmall reverberatory furnace which was already conſtructed for experiments of this kind.

The oxygen gas was to be introduced through water into one of the funnels, as faſt as the cumbuſtion might require it; and any reſidue of Azot or other matter was to be ſaved in the oppoſite funnel previouſly filled with water or mercury. For the ſtop-cock of this funnel was not to be opened, until the combuſtion commenced.

An inſtrument anſwering to this deſcription being provided, the following experiment was made at a ſubſequent meeting.

The glaſs tube was five feet in length, and an inch in diameter, and was coated with clay at the part which was to be heated. Being placed horizontally acroſs the bed of the furnace, and luted to the walls; the tube projected by each of the uncoated ends, about twelve inches from the wall. A ſlender ingot of Zinc weighing an ounce, was placed in the middle of the tube; and at the diſtance of a foot from the Ingot, a little embankment of white ſand was made, to prevent the metal

from running to either end of the tube during the decrepitating combuſtion which was to be expected.

The funnels and ſtop-cocks being ſcrewed on, and perfectly air tight; and one of them being charged with oxygen gas communicating with the Zinc; it now occurred to the experimenter, that the firſt trial ought not to be made in the preſence of the ſociety.

For if the ſupply of oxygen gas ſhould not be as quick as the abſorption of it by the Zinc, the water might ruſh into the red-hot tube and melted metal, before the aſſiſtant could turn the cock, and the exploſion might endanger the ſpectators as well as the experimenters. It was alſo apprehended that an exploſion might take place from another cauſe.

The experimenter had formerly obſerved that a mixture of hydrogen and oxygen gaſſes, when greatly dilated, either by gradual heat, or in conſequence of the preſſure of the air being averted, requires a much larger electrical ſpark, or greater ignition, for the inflammation, than is neceſſary in the denſer ſtate of them. A great quantity of inflammable vapour of Zinc might therefore

mix

mix with the oxygen gas in the tube and funnel, before the ignition of any part was sufficient for the commencement of the combustion: and in this case the explosion would be dangerous. It was therefore resolved that these funnels should not be used, until the velocity and other circumstances of the combustion should be ascertained.

The funnels being removed, the air was chased out of the glass tube containing the Zinc, by pressing oxygen gas through it, from a bladder which was screwed to one end. When this bladder was emptied, the cocks were closed; and a bladder containing nine pints of oxygen gas, and provided with a stop-cock, was screwed to the other end of the tube.

The temperature of the gas when measured was 60°: The barometer standing at 30 inches.

When fire was applied to heat the Zinc, proper measures were taken, with respect to the parts of the instrument which projected on either side out of the furnace, to secure the spectators from all danger; in the case of explosion. When the Zinc was supposed to be sufficiently heated, the cocks were opened,

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in conſequence of which the oxygen gas of the filled bladder paſſed ſlowly through the ſlender aperture of the cock, over the Zinc and into the empty bladder. When about half a pint had thus paſſed, the Zinc being more heated, catched fire, and burned with briſk decrepitation, and a brilliant light, which ſeemed to fill the uncoated parts of the tube and the diſtended bladder.

In the courſe of a minute the whole of the oxygen gas was conſumed; two or three cubic inches excepted, which could not enter, becauſe the flaccid bladder hung againſt the ſlender tube of the cock and ſtopped it.

During the combuſtion, one of the aſſiſtants, who was placed for this purpoſe, preſſed in all the oxygen gas which had paſſed into the ſmaller bladder, before the Zinc had catched fire; and having done this he ſtopped the cock on that ſide, ſoon after the Zinc had catched fire.

It was already manifeſt that the oxygen gas was pure, and that all that entered was expended in the oxydation of the Zinc, and the generation of Caloric and Light.

After an interval of about a minute, many of the members expreſſed a deſire, that the

ſmall

ſmall quantity of gas remaining in the flaccid bladder ſhould be introduced, to prove that there was no azotic reſidue.

The experimenter knew that the whole of the Zinc was not oxydated, and that the tube was charged with metallic vapour; and conſequently expected a ſmall exploſion.

It happened that the flaccid bladder had depoſited a drop or two of water in the mouth of the ſtop-cock, againſt which it was preſſed by the air. This water, in a tube of only $\frac{1}{16}$ of an inch in diameter, made ſome reſiſtance to the entry of the oxygen gas; and perhaps the metallic vapour which might now have filled the glaſs tube had contributed to the reſiſtance.

The water gave way when the bladder was preſſed a little; the oxygen gas entered ſuddenly, and cauſed a loud exploſion, but not ſo great as to break the glaſs tube.

This afforded an explanation of the exploſion which formerly endangered Mr. Young, and warranted the deviation which the experimenter had made from the experiment with the glaſs funnels.

Dr. Latham who was attentive to this experiment, expreſſed a different opinion

of

of the explosion. For, knowing that the cock was stopped with water, and that the hot vapour of Zinc was capable of decomposing water and detaching its hydrogen; he imputed the explosion to this mixture of hydrogen gas with the oxygen gas, in contact with the flaming metal. Other members concurred in this opinion at the moment. But some, who observed that the glass tube, where it passed the wall of the furnace, and was heated in the uncoated part, was bent downwards by the weight of the cock and bladder, before the explosion took place, entertained the opinion expressed by the experimenter; thinking it highly improbable that the water which stopped the cock could have moved in the direction of the flexure of the tube, twelve inches or more to meet the hot part of the metallic vapour.

After the explosion the fire was immediately withdrawn; and the glass tube was gradually cooled. It was found to contain 36 grains of Zinc in one mass, and 18 dt. 12. gr. of white oxyd, lined with a thin stratum of semi-oxydated metal, to the length of two feet. The oxyd being first formed, was attached to the glass tube by the external surface;

face; but on the internal ſurface, the oxyd was covered by the metallic film which was formed by the condenſation of the metallic vapour, after the exploſion and during the cooling.

A viſitor having formerly mentioned in the ſociety, that he had expoſed Carbonic acid gas of experienced purity to boiling mercury in cloſed veſſels, for three hours; and found the mercury oxydated at the ſurface; and only $\frac{7}{8}$ of the gas remaining; this remainder, he ſaid, conſiſted chiefly of azotic gas. It was the general opinion that he had been deceived by ſome unknown accident; but it was agreed that the Experiment ſhould be repeated for the ſociety.

Dr. LATHAM at the ſame time made ſeveral ingenious obſervations on this ſubject; and concluded with the following queſtion.

"Whether in the oxydation of Mercury "by Carbonic acid gas, the Mercury may "not unite with the Carbo (as Iron in its "converſion to ſteel) and after that union "eaſily

" eafily unite with the oxygenous gas, fo as
" to become an oxyde ?"

The veffel in which the gentleman wifhed the experiment to be made was a fmall glafs retort with a long neck, and a receiver open at the bottom; all blown in one piece.

To exhauft it of air compleatly, it was filled with hot Mercury; and the open end being funk in the trough of Mercury, Carbonic acid gas was thrown up to difplace the Mercury, and mingle with any air which might have been intercepted between the Mercury and the veffel, in the former filling. The Carbonic acid gas was next expelled by depreffing the veffel under Mercury; and in filling the veffel again with acid gas eight ounces of Mercury were left in the retort, expofed to 25 cubic inches of the gas. The barometer being 30, the thermometer 55°.

The open end of the recipient being funk in mercury, the retort was placed in a fand bath; and whilft the mercury was kept in a boiling heat for fix days, the recipient was repeatedly depreffed and raifed in the mercurial trough, to pump the Carbonic acid gas from one veffel to the other, and expofe it fully to the mercury.

Notwithſtanding all this, the mercury retained its metallic luſtre and there was no appearance of oxyd of mercury, nor any diminution of the volume of the Carbonic acid gas.

The gas was procured from powdered calcareous ſpar, which was agitated in hot diſtilled water for ſome minutes, before the ſulphuric acid was uſed.

This laſt was introduced by a long cylindrical tube terminating in a capillary opening, and provided with a ſtopper; ſo that the acid might paſs into the water ſlowly from the ſlender extremity of the tube; and that its deſcent might be checked at pleaſure, by introducing the ſtopper, when the effervefcence was ſufficiently briſk.

The ſmall quantity of air included with the ſpar and water, was carefully expelled, at the expence of twenty times its bulk of gas which paſſed off to waſte.

The purity of this gas was tried by expoſing 94 cubic inches of it to Lime water recently made with boiling diſtilled water and pure lime; and only one cubic inch, or leſs than one remained unabſorbed.

This reſidue was azotic gas; and therefore the

the gas expofed to the mercury fcarcely contained $\frac{1}{150}$ of its weight of azotic gas, previous to the experiment.

Being examined after the foregoing expofure to the boiling mercury, it was found to have undergone no alteration.

Mr. Young read a fhort extract from the late publication of Monf. Pictet; which confifted of arguments in oppofition to the notion of Caloric being Chemically combinable in bodies; but concluded with an acknowledgment that in fome inftances, the evidence for intimate or Chemical combination was very ftrong.

A member obferved that the writer who admits any fuch attractions of Caloric, would eafily be perfuaded by further obfervation and experience, to admit all that was advanced on this fubject.

Phof-

Phoſphoric proceſſes which require much time, being announced for the enſuing week; converſations aroſe, on the phoſphoric bodies of this kind; in which a viſitor mentioned an experiment, the particulars of which were afterwards delivered in writing, and inſerted in the next minutes.

MINUTES

OF THE

FIFTEENTH MEETING,

ON

SATURDAY, May 17, 1794.

Menſurations of Caloric.

Frigorific Experiments.

Oxygenation of Phoſphorus.

Phoſphoric Proceſſes and Experiments.

FROM the known property of bodies to combine with Caloric, and alſo to engage additional and ſmaller quantities of this matter, in a ſtate of weaker adheſion, ſuch as that in which it cauſes their fluidity or temperature; from the apparent gradations of the forces with which different bodies attract Ca-

Caloric; and from the unequal aptitude of bodies for the reception or tranſmiſſion of this ſubtile matter; it was argued that the ingenious experiments of Dr. CRAWFORD and other authors whom he cites, for aſcertaining the capacities of bodies for Caloric, afford no ſolid data from which the abſolute quantities of this matter can be computed.

Some paſſages of Dr. CRAWFORD between 29 and 71 pages were cited, preparatory to experiments which were now exhibited as they were deſcribed by this author, between the 71ſt and 83d page.

The Calorimeter of LAVOISIER, page 421, being ſhewn in all its parts, was charged with about 80 pounds of pounded ice, and applied to uſe, in meaſuring the Caloric emitted during the ſpontaneous refrigeration of red hot iron, and of other bodies. LAVOISIER's inſtructions on this ſubject were recommended.

As the air of the Laboratory was highly charged with aqueous vapour of Reſpiration, and of the wax lights, a fog appeared around the Calorimeter, and condenſing on it, trickled by drops in quick ſucceſſion, from the lower part of it. During this evening, an aſ-

fiſtant was employed in preventing theſe drops from mixing with the water produced from the internal compartment of the Calorimeter. But againſt the next meeting of the ſociety, the ſtop-cock was provided with a cap which rendered the attendance of an affiſtant unneceſſary.

In the firſt experiments with this inſtrument, it was obſerved that the water trickled from the internal compartment at the temperature of 33°, inſtead of 32° the proper temperature of water dropping from ice. This ſhewed that the Calorimeter of LAVOISIER was not well adapted to experiments carried on in a warm room; and therefore an alteration was made; by which the ice was lowered to the middle of the cock, and the water from the ice iſſued at the temperature required.

As each experiment with the Calorimeter laſted many hours without requiring much attendance; other experiments ſhewing the phenomena of frigorific mixtures were introduced at theſe intervals. As they were to be performed in a place warmed to 70°, a large veſſel was provided, which had two compartments. An external, like that of the

Ca-

Calorimeter, in which a frigorific mixture was placed to ſurround the internal compartment in which the experiment was to be made, and to prevent the temperature of the place from reaching it.

Equal parts of muriated ammoniac and Nitrat of Pot-aſh, or Salt-petre, being well dried and mixed in powder, were blended with water, in the proportion of three parts of the ſalts to four of the water, in the external compartment, and the hollow cover which made a part of it.

The internal compartment was charged with a mixture of the ſame kind; and both being agitated to promote the ſolution of the ſalt; a ſmall veſſel filled with water was placed in the internal compartment.

A thermometer placed in the frigorific mixture of the internal compartment ſunk in a few minutes 28 degrees below the freezing point. If the cover of the external veſſel had not been often removed, the mercury in the thermometer would have ſunk 35 or 36° below the freezing point.

During the refrigeration of the water in the central veſſel, below the freezing point, and during the ſubſequent congelation of it;

obſervations were made in the manner of Dr. CRAWFORD on theſe ſubjects.

Another frigorific mixture was made, to the like effect, with pounded ice and nitrous acid previouſly diluted in the method of Mr. CAVENDISH, and cooled. And it was obſerved that all other frigorific mixtures and ſolutions act on the like principles.

After an enumeration of the various inſtances of incaleſcence and combuſtion, by the action of bodies on each other; it was argued that as Caloric is always liberated, and the temperature always augmented, during the approximation and union of particles carrying charges of Caloric in the manner formerly deſcribed; every ſeparation of ſuch particles, during the ſolution of an aggregate, muſt be attended with a reſumption of this matter from the free Caloric of temperature; and conſequently with the phenomena of refrigeration.

This was repreſented as the true cauſe of every refrigeration hitherto effected by the ſolution or expanſion of bodies. On this occaſion reference was made to all the experiments formerly ſhewn; in which cold was produced by the expanſion of Ether, Ammoniac

and other bodies; or during the ſolution of ſalts or ice: the liquefaction of a body conſiſting of attractive particles, being the ſtrongeſt analogical proof of the ſeparation of its parts by interceding Caloric.

A glaſs jar which was round and thin at the bottom, to ſecure it from cracking by the heat, was ſunk in a trough of Mercury and waſhed with oxygen gas, and was then charged with 19.25 grains of oxygen gas from red oxyde of mercury by Nitrous acid. A ſhallow Iron diſh was made to float on the Mercury in the Jar, and a long flat piece of pure Phoſphorus well dried in blotting paper, and weighing 15 grains, was placed in the Iron diſh. The Experimenter then holding the jar upright by means of an Iron clip, and preſſing it a little into the mercury, inflamed the Phoſphorus by means of the crooked Iron wire of LAVOISIER, page 104.

During the brilliant and rapid combuſtion of the Phoſphorus, the jar was filled with white vapour, the oxygen gas contracted in

volume, the mercury rofe, and the jar was fuffered to fink. When the veffel had cooled, and the mercury was brought to the fame level on the infide and outfide of the jar, the volume of the remaining gas was lefs than $\frac{1}{200}$ of the whole.

Water being admitted to deprefs the mercury and diffolve the phofphoric acid which was vifible between the fides of the veffel and the mercury; the unburned phofphorus was found to weigh about 2.5 grains.

After divers repetitions of the like combuftion with different quantities of phofphorus, the experimenter acquiefced entirely in the conclufion of LAVOISIER, page 106. "When we reduce thefe weights to hun- " dreth parts, it will be found that 100 " parts of phofphorus require 154 of oxygen " for faturation, and that this combination " will produce 254 parts of concrete phof- " phoric acid."

Thus a volatile combuftible body which was infoluble in water, and had fcarcely any tafte was changed by this union with oxygen into an acid very four and foluble, perfectly incombuftible, and capable of fuftaining a red heat without evaporating.

The

The whole of the reaſoning of LAVOISIER on this oxygenation, and his menſurations of the Caloric emitted when phoſphorus is burned with oxygen gas in the Calorimeter, were adopted by the experimenter and are now referred to in the minutes.

Pure Phoſphorus was in the next place oxygenated in another manner. Into a cylindrical veſſel terminating with a round bottom like that uſed in the laſt experiment, and of equal capacity, twenty grains of phoſphorus were paſſed through mercury to riſe to the round bottom of the veſſel above the mercury. The veſſel ſtanding firmly in mercury with the round bottom upwards, was heated by an Iron bar applied to the center of the bottom, until the phoſphorus melted and boiled without combuſtion or illumination.

As the veſſel cooled, the phoſphorus concreted to its bottom and lined the whole of it. The quantity of phoſphorus thus employed being known; a cubic inch of oxygen gas was thrown up to depreſs the mercury and meet the phoſphoric incruſtation.

The abſorption of the gas being very ſlow, and producing a very weak light ſimilar to that of phoſphorus expoſed to cold air, it was

per-

perceived that the acid which formed a film upon it impeded the oxygenation, which might however be accelerated by warming the phoſphorus.

Several cubic inches of oxygen gas were ſucceſſively introduced as faſt as they were abſorbed by the warmed phoſphorus, to ſhew the weak light which phoſphorus yields when it is ſlowly oxygenated.—All this time a white cloud deſcended from the phoſphorus, and concreted into white fleecy flakes of Phoſphoric acid.

A larger meaſure of the gas being now introduced, and the phoſphorus being more heated than before, it catched fire and burned with a brilliant flame until all the gas was conſumed. As often as freſh gas was introduced the combuſtion was renewed; the quantity of reſiduary azotic gas was very ſmall; and thus great quantities of phoſphorus and oxygen gas might be expended in the formation of phoſphoric acid in the upper part of the quart jar, and the whole of the phoſphorus might be burned, by heating the upper half of the jar containing the laſt charge of the gas.

When phoſphorus is expoſed to air at a

mean

mean temperature, the acid which is immediately formed attracts moiſture, and both retard or ſtop the progreſs of the oxygenation. In certain circumſtances the phoſphorus attracts oxygen quickly from the air at low temperatures, and catching fire, is ſoon conſumed. This was ſoon ſhewn by wrapping a piece of phoſphorus quickly in dry tow, and ſqueezing it ſtrongly with pinchers, to make it ſpread into the tow.

As ſoon as the tow was drawn aſunder, ſo as to expoſe the phoſphorus with dry and extended ſurfaces to the air, it became luminous and preſently catched fire.

Various other methods were mentioned, in which the mere diviſion of the phoſphorus had been found to accelerate the oxygenation and inflammation; and phoſphuret of Lime being ſhewn, which catched fire in the firſt inſtant of its contact with air, it was obſerved that the ſpeedy accenſion depended chiefly on the diviſion of the phoſphorus.

In regard to the following descriptions of processes, and all others which appear in the minutes, it is to be observed that they are written under the supposition that the modern chemical school-books, such as FOURCROY'S, NICHOLSON'S, and CHAPTAL'S, have been consulted by the reader; and that he wishes for no more than a clear exposition of the improvements in prescription and practice.

To prepare phosphoric acid twenty pounds of the powder of bones slowly burned to whiteness in a current of air, were diffused in twenty gallons of boiling water; and ten pounds of sulphuric acid previously diluted with an equal weight of water, were gradually added. The whole was kept in motion, during the action of the acid, and for half an hour afterwards; and was then poured into a filtering bag made of cotton cloth. When the filtration became tardy, it was renewed by pressing the bag at the sides, so as to agitate the mass.

Fresh water was poured into the conical cavity of the selenitic mass, to keep it almost filled, until ten gallons more had been thus expended in washing out the phosphoric acid.

The filtered liquor was neutralized by mild volatile alkaline ſalt; a ſmall exceſs of the alkali being diſregarded. After the neutral liquor became clear, it was poured off, from the earthly ſubſidence, and evaporated ſlowly in a ſhallow Leaden boiler, until it was reduced ſo far that it might depoſite cryſtals by cooling.

It was poured, whilſt hot, into a thin glaſs balloon; which was placed on the ſand bed of a reverberatory furnace.

The mouth of the balloon being covered with an inverted crucible; the fire was gradually raiſed to act on the charge from above downwards, and was continued with due caution until the bottom was obſcurely red.

In this way the ſulphat of ammoniac was ſublimed out of the phoſphoric ſalt; the ammoniac which neutralized the phoſphoric acid was alſo expelled; and the phoſphoric acid remained in the form of a colourleſs tranſparent glaſs, which was eaſily ſeparable when cold, from the veſſel, by the blow of a hammer, or the edge of a knife.

Thus the inconveniencies of every proceſs hitherto deſcribed for this purpoſe, were avoided.

Phoſ-

Phoſphoric acid freed from earthly matter, and having this glacial appearance, has generally been conſidered as pure; but in certain applications of it, the experimenter found that it contained a certain quantity of ammoniac, which was inſeparable from it by this degree of heat. To this he chiefly imputed the great quantities of azotic and hydrogen gaſſes, which appeared in the reduction of this acid to Phoſphorus.

Sixteen ounces of this glacial acid were pounded with eight ounces of charcoal powder in a hot Iron mortar, and the mixture was introduced into an earthen retort which it filled.

This quantity of charcoal was not neceſſary to the formation of phoſphorus; but was employed to engage the phoſphoric acid, and to prevent it from preying on the veſſel, and forming glaſs inſtead of phoſphorus.

The retort, previous to the uſe of it, was waſhed externally with a ſtrong ſolution of two parts of Borax mixed with one of Lime; to cloſe the pores, and form a coat of glaſs, during the incandeſcence of the veſſel. It was alſo lined internally near the bottom with charcoal powder; and being duly placed on the bed

bed of a reverberatory furnace, the neck was elongated by luting to it a copper tube, which made the whole length of the neck 22 inches. Glue lute was uſed for this purpoſe; and the end of the copper tube was barely covered with water. A greater length of the neck was repreſented as unneceſſary; all the phoſphorus that can be ſaved, being always found in a concrete ſtate, within twelve inches from the wall of the furnace; when the diſtillation is ſlow and attended with the ſmalleſt waſte.

The fire was applied gradually for two hours or more, before the heat was ſufficient to melt the phoſphoric acid; in order to make the charge as dry as poſſible, and to leſſen the commotion which is apt to throw the charcoal upwards and expoſe the retort to the action of the acid.

During the diſtillation with a greater heat, the water, which was impregnated with the fuliginous and ſaline impurities firſt carried over, was removed, before the phoſphoric matter began to riſe; and afterwards due care was taken that the concrete phoſphorus ſhould not block up the neck, and prevent the free eſcape of the elaſtic fluids.

This

This was done in the preſent inſtance, by the uſe of a wide necked veſſel: and it was ſhewn that the phoſphorus may be melted out of a narrower neck, by placing an hot bar of iron under it.

" When the efflux of elaſtic fluids ceaſes in " conſequence of a ſtoppage of this kind, an " exploſion of the retort follows in a few mi- " nutes, if the neck be not heated."

The elaſtic fluid which iſſued through the water during the diſtillation of the phoſphorus, ſhewed a weak and lambent light, ſimilar to that of cold phoſphorus, where it mounted in the air; but when received in veſſels void of air it ſhewed nothing luminous.

When confined by a funnel inverted on the water, it was luminous only at the tube of the funnel where it met the air; and here it flaſhed at the approach of a taper, and when inflamed, continued to burn.

Succeſſive portions of this elaſtic fluid were ſhewn to conſiſt of carbonic acid gas mixed with between $\frac{1}{13}$ and $\frac{1}{25}$ of hydrogen gas and phoſphorus impregnated with a ſmall quantity of azotic gas. The former was ſaid to be the natural product of Carbo combined with the

oxygen

oxygen of the phoſphoric acid; whilſt the hydrogen gas proceeded chiefly from the aqueous matter introduced by the Carbo, the moiſt retort and the deliqueſcent acid, and perhaps partly from the ammoniac above mentioned. The ſmall quantity of azotic gas was imputed to the charcoal which yields ſome azot in every decompoſition of it; and partly to the ammoniac of which it is a conſtituent principle.

" Any of theſe gaſſes waſting phoſphorus " when it is extremely divided, is capable " of holding a part of it ſuſpended for a con- " ſiderable time; but carbonated hydrogen " gas retains it with the greater obſtinacy."

The phoſphorated inflammable gas of this diſtillation, being ſeparated from the Carbonic acid gas, and at the ſame time diveſted of the greater part of the phoſphorus, and being mixed with oxygen gas, and inflamed by a ſpark, exploded like hydrogen gas fired in the ſame way; but being gradually burned at the mouth of a bottle, ſhewed the phoſphoric and carbonic impregnation.

" Phoſphorated hydrogen unwaſhed and " carrying its full charge of Phoſphorus, " catches fire by the mere agency of air."

In consequence of the waste of phosphorus thus unavoidably wasted away by incoercible fluids, equal in weight to the whole of the phosphoric acid employed, the quantity of Phosphorus saved was scarcely four ounces.

If the distillation had been carried on more quickly, the produce would have been proportionally less; for all that passed in a state of division into the water, underwent a partial decomposition which rendered it useless.

It was stated on grounds which are presently to be described, that the above charge of phosphoric acid, supposing it to be pure, contained 6¼ ounces of Phosphorus; and that so much would have been found, if the whole could have been saved.

Whilst the retort was cooling, some of the gas of the process was introduced into the neck, to prevent the water from being pressed into it.

When it had cooled to the temperature of the air, the neck of the retort was broken quickly into water, and the wetted mass of phosphorus, none of which reached to the copper tube, was taken out.

If the retort were otherwise opened, the film and powder of Phosphorus which lined a part

a part of the neck, would have catched fire by the mere expofure to air, and would have inflamed the mafs.

The charcoal remaining in the retort, was quite friable or powdery.

The experiment mentioned by a vifitor at the laft meeting was now defcribed.

He faid that " he had expofed thirty cu-
" bic inches of pure hydrogen gas to phof-
" phorus; both being confined by mercury,
" at the temperature of 60°. Eight cubic
" inches of the gas were abforbed, and the
" phofphorus became liquid acid. The mer-
" cury was covered with a black film: And
" the remaining gas was found to confift of
" hydrogen gas mixed with $\frac{1}{10}$ of its bulk of
" oxygen gas, by the nitrous teft."

It was not deemed neceffary to follow this experiment in all its circumftances; until the rectification of phofphorus which was now carried on, and which was competent to decide on this fubject, fhould be finifhed.

Dr. Powel in the mean time faid that
" he had made the defcribed experiment with

"phoſphorus and hydrogen gas. He had "obſerved a diminution of the volume of "the gas, and the film on the mercury; but "he found no acid."

The experimenter ſaid that phoſphorus is ſoluble to a certain quantity in hydrogen gas; that air admitted to phoſphorated hydrogen, inflames it; and that the product is phoſphoric acid and water. Having often in the courſe of twenty years uſed hydrogen gas in the rectification of phoſphorus, he obſerved a part of the hydrogen gas was expended in the ſolution of phoſphorus, but nothing like the production of oxygen gas or the formation of acid.

The proceſs for rectifying phoſphorus and applying hydrogen gas was now ſhewn and deſcribed.

The phoſphorus of the former proceſs had the colour and opacity of the Common Reſin called Black Reſin; and was viſibly tainted with the fuliginous matter carried up with the elaſtic fluids.

To purify ſuch phoſphorus for experimental uſe, eight ounces were taken from the

products of former processes and treated in the following manner.

A wide necked retort, capable of holding half a pint of water in the body, was charged with distilled water; and then with the phosphorus in pieces as large as the neck would admit.

The retort was heated in hot sand until the phosphorus melted and subsided under the water. The whole being cooled, the phosphorus adhered to the retort; and the water was expelled by hydrogen gas, which was confined by sinking the mouth of the retort under water.

The retort was then placed in sand which covered the helm and part of the neck, and fire was gradually applied.

During the distillation, and especially about the commencement of it, due care was taken that the water into which the phosphorus was to be distilled, should not be forced into the retort, in consequence of the condensation of the aqueous vapour which depressed it.

As the distilled phosphorus concreted in the neck of the retort, and would have blocked it up entirely; hot water was poured on this

part until the phoſphorus melted and ſank in the water.

The diſtillation being carried on ſlowly and ſteadily, the phoſphorus thus rectified was nearly as tranſparent and colourleſs as gum copal.

When any ſpray from the effervefcing martial ſolution, is permitted to enter the water which receives the phoſphorus, this laſt is affected by the martial matter, in the manner of a vegetable aſtringent; for the phoſphorus becomes opaque and blackened; a circumſtance from which inferences may be drawn, which do not belong to this place.

During this diſtillation, and repeated applications of hydrogen gas at night; the candles being removed and the place compleatly darkened; no light or combuſtion appeared upon the entry of the hydrogen or afterwards, to Mr. HYATT and two experimenters who attended.

This uſe of hydrogen gas in the rectification of phoſphorus, ſhewed that the learned gentleman who ſuggeſted the experiment, muſt have been deceived by ſome circumſtance which he had not noticed. For if $\frac{1}{20}$ or $\frac{1}{50}$ of the bulk of the hydrogen gas introduced, had

had aſſumed the properties of oxygen gas; the phoſphorus would become lucid after every change of hydrogen gas; and the half pint of water which ſerved to cover the mouth of the retort, would have diſcovered conſiderable acidity. But the phoſphorus was never luminous, and the water contracted no ſourneſs, during ſix hours, in which about four pints of hydrogen gas were introduced, and expended in forming phoſphorated hydrogen gas, which occaſionally paſſed through the water, and flaſhed at the ſurface.

MINUTES

OF THE

SIXTEENTH MEETING,

ON

SATURDAY, May 24, 1794.

Oxygenations of Charcoal, Alkohol, Sulphur, Pyrophori, Phosphorated Hydrogen Gas.

PROCESSES.

AS the arrangements neceſſary for the oxygenation of bodies, in meaſured quantities of oxygen gas or air, generally required much time, although the impreſſive phenomena were exhibited in a few minutes; the experiments of this kind were introduced at different meetings, when the ſlow and uniform progreſs of others admitted of it. They are here drawn together in the order fitteſt for conciſe deſcription.

Charcoal was placed in oxygen gas in the manner of the experiment of LAVOISIER, page

114,

112, to be inflamed at a more convenient time; the great mercurial trough being now engaged.

An experiment anſwering the ſame purpoſes was performed as follows.

A ſmall piece of charcoal heated to redneſs at one of its angles, and weighed in this ſtate, was placed in a flat iron cup, which floated in the mercury of a deep mercurial trough. A ſtrong glaſs bottle which had a long neck wide enough to receive the iron cup, and which was filled with three pints of oxygen gas, was quickly placed over the cup and depreſſed forcibly into the mercury, to prevent any part of the gas from eſcaping during the dilatation.

The combuſtion was rapid and brilliant, with crackling ſcintillations, at the beginning; but grew weaker by degrees, until it was extinguiſhed by the Carbonic acid gas produced by the union of the oxygen with the carbo of the coal.

When the charcoal remaining in this experiment, or in that of LAVOISIER, was weighed; and when the carbonic acid gas of each, ſeparated from the reſiduary oxygen gas, was meaſured, it appeared that the carbo

and

and oxygen combined nearly in the proportion of 28 to 72 by weight, to form 100 of carbonic acid gas: and that the weight of this laſt was nearly equal to the ſum of the weights of the conſumed carbo and oxygen; notwithſtanding the eſcape of the Caloric and Light.

A ſmall long necked retort was charged with eight ounces of oxyd of mercury by nitrous acid, and half an ounce of charcoal finely powdered and placed over the oxyd. The body of the retort was ſunk in the ſand bed of a reverberatory furnace, to the depth of the oxyd, and the fire was applied to redden the charcoal, before the oxyd.

As charcoal imbibes moiſture which cannot be expelled from it by leſs than a red heat; in which the water is decompoſed and expended in the formation of Carbonic acid gas and hydrogen gas; and as this quantity of Charcoal was too great to be conſumed by the oxygen of the oxyd, it was expected that ſome hydrogen gas would accompany the Carbonic acid gas from this charge.

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The event of the experiment was, that none of the oxygen gas eſcaped the charcoal. The mercury of the oxyd paſſed into the water through which the elaſtic fluid was gradually delivered; and this laſt conſiſted of Carbonic acid gas, containing a very ſmall quantity, by weight, of hydrogen and azotic gas.

In this way the weight of the carbonic acid gas might eaſily be aſcertained; for the weight of the oxygen of the pure oxyd, was that by which the oxyd exceeded the mercury depoſited in the water; the weight of unconſumed charcoal ſhewing the quantity of Carbo expended in the formation of carbonic acid gas, ſome allowance being made for the ſmall quantity of hydrogen gas and azotic gas which appear in theſe and in all combuſtions of charcoal.

A ſmall quantity of Alkohol was burned in oxygen gas, ſo as to ſhew that the product was Carbonic acid gas and water, excluſive of the emitted Caloric; and that Carbo and hydrogen are the chief principles of ſpirit of wine.

At

At this meeting and ſeveral others, Alkohol was ſlowly burned with atmoſpheric air in the inſtrument deſcribed by LAVOISIER, page 517.

The Carbonic acid gas and water produced in this proceſs, were obſerved by Mr. LEWIS to have an Empyreumatic ſmell. And notwithſtanding the great quantity of the alkohol expended in the formation of the gas, the water ſaved in the refrigeratory, exceeded the alkohol in weight.

Mr. GRANT made a very juſt remark on this ſubject. He ſaid that the heated air alone would depoſite moiſture in paſſing thro' the refrigeratory; and in a combuſtion carried on ſo ſlowly, the water thus depoſited, might equal or exceed that which was formed by the union of oxygen with the hydrogen of the alkohol.

The

The combuſtion of Sulphur in oxygen gas, and the converſion of it by the oxygen into ſulphureous acid, was ſhewn in the ſame way.

The proceſs of the manufacturers of Sulphuric acid, was alſo exhibited in a veſſel which was large enough to admit a dram of the ſulphur to be introduced and inflamed at once. Many ſucceſſive charges conſiſting of the ſulphur mixed with $\frac{1}{8}$ of Nitre, were conſumed; the air aſſiſting the oxygen of the Nitre, in maintaining the combuſtion and the converſion of the ſulphur to Acid; and a ſmall quantity of water placed in the veſſel, ſerving to facilitate the condenſation of the Acid Vapour.

The method of compleating the oxygenation and concentrating the weak acid thus prepared, by diſtillation in veſſels acceſſible to air, was alſo ſhewn.

Pyro-

Pyrophori being reprefented as fpongy bodies, in which combuftible matter, fuch as Carbo and Sulphur, may be expofed to air, in circumftances highly favourable to the quick oxygenation and combuftion of them; a fpecimen of Pyrophorus made with alum and flour was produced; which was fo vigorous as to enter into combuftion as faft as it fell from the mouth of a bottle in which it was made. The bottle being held high before it was opened and inverted, the fparkling ftream of inflamed powder reached from the mouth of it to the ground.

After fhewing the products of this combuftion in meafured quantities of atmofpheric air; the Experimenter gradually introduced about fixty grains of the Pyrophorus into a pint of oxygen gas, through mercury. The combuftion which was very brilliant, took place at the inftant of the mixture: the oxygen gas difappeared, and its place was occupied by fulphureous gas and Carbonic acid gas. The folid refidue of the pyrophorus, was Argil and embryon alum flightly coloured with Carbo, which being defended by the argil, efcaped the combuftion.

To burn and oxygenate the pyrophorus perfectly, the narrow neck of one of the ſmall bottles of pyrophorus hereafter to be deſcribed, was inverted to ſtop the mouth of a large bottle containing a quart of pure oxygen gas. As the pyrophorus fell from the upper bottle, it exhibited a fiery brilliant ſtream, and the reſidue of the heated and half-burnt pyrophorus, accumulated at the bottom of the lower bottle, was burned nearly to the proper whiteneſs of the argillaceous matter.

The perfection of the pyrophorus employed in theſe experiments, induced a member to deſire that the proceſs ſhould be deſcribed in the minutes.

Three parts of Roman alum were mixed with one of flour in an iron pot. The maſs was agitated during the liquefaction by heat, and the dried parts were broken into the liquid, by an iron ſpathula, until the whole became grey and pulverable whilſt hot. The heat was ſlowly augmented and equally applied to all parts of the mixture, and care was taken towards the end of the proceſs to prevent any adheſion of the maſs to the pot.

Twelve

Twelve ounce phials of green glaſs were ſlightly coated with white clay. For this purpoſe the clay was diffuſed in water to give it the ſpiſſitude of cream. The bottles were waſhed externally and internally with this liquor; and placed in a warm place where they were often turned, until the thin coating became even and dry.

The bottles thus prepared were filled from the dry maſs above mentioned, broken into coarſe powder; and were placed in an iron pot, with ſand to ſurround and ſuppott them at equal diſtances and to the ſame height.

A ſmall ball of plaſtic clay was ſlightly preſſed on the mouth of each bottle; and the ſand was raiſed to ſtand even with the mouths. Charcoal powder was placed over theſe to the depth of half an inch, and laſtly an earthen cover was luted to the pot.

The purpoſes were to allow a free paſſage to the elaſtic fluids which were to iſſue; and to prevent any air from returning into the bottles, before it had depoſited its oxygen in the charcoal. The iron pot thus charged was heated to redneſs; and this heat was maintained for an hour and an half. It was

then

then raiſed out of the furnace and ſuffered to cool quickly.

When all was cold, the bottles with their ſtoppers of clay were placed with the mouths inverted in mercury.

The experimenter ſaid that the pyrophorus may thus be kept for many years unimpaired.

In this proceſs the oxygen of the ſulphuric acid of the alum is expended in the formation of Carbonic acid gas, with the charred flour; and the reſiduary ſulphur and Carbo diffuſed in the ſpongy maſs of Argil, form the pyrophorus which imbibes oxygen gas by capillary attraction, and preſents theſe combuſtible principles to it, in a ſtate of extreme diviſion.

As farinaceous and ſaccharine bodies, and vegetables in general contain ſome phoſphoric matter, it is poſſible that a ſmall portion of phoſphorus may ſubſiſt in pyrophori of this kind. But the extreme diviſion of the carbo and ſulphur and the ſpongineſs of the beſt pyrophori, appear to be chiefly inſtrumental in the quick and ſpontaneous aſcenſion of them in air.

To illuſtrate the effect of the ſpongy texture, a piece of light charcoal, intenſely heat-

ed, and quickly introduced into a veſſel containing ſix times its bulk of air confined over mercury, in the manner of the Abbe FONTANA, was ſhewn to abſorb the whole of the azotic as well as the oxygen gas, and conſequently to condenſe the azotic gas to a great degree by mere capillary attraction; for it was obſerved that the experiment ſucceeds with any gas.

Phoſphuret of lime was prepared in the following manner.

A long phial which the following ingredients might fill exactly, an ounce of ſtone lime in coarſe powder, and half an ounce of phoſphorus cut into ſmall pieces, being provided; about half a dram of the lime was introduced into the bottle, then half this quantity of the phoſphorus dried in blotting paper; and the remaining lime and phoſphorus were added in alternate ſtrata. The bottle ſtood in water cooled by ice, and being looſely ſtopped with a cork, was removed into a ſand pot and ſurrounded, to the height of the neck, with warm ſand. The heat was encreaſed quickly and

and continued, until the lime appeared to be uniformly impregnated, and to have acquired an auburn colour.

When the bottle was removed from the ſand which was heated almoſt to redneſs, the cork, which before permitted the eſcape of the redundant phoſphorus, in form of combuſtible vapour, was preſſed in, to prevent the entry of air during the cooling.

If leſs of the phoſphorus had been expelled, the phoſphuret would have cooled to a hard maſs; if much more had been evaporated by a greater heat, the phoſphuret would have been effete and unfit for the uſe to which it was to be applied.

The phoſphuret thus duly prepared, was friable and eaſily broken in the bottle when cold, by means of an iron wire.

Half an ounce of it poured into a wine glaſs almoſt filled with water, the mouth of the bottle being held cloſe to the water, ſoon preſented the expected phenomena; but not ſo well as Phoſphuret uſed in the following manner.

One of the bottles charged in the foregoing method with Phoſphuret of Lime, was ſunk in a conical veſſel filled with a pint of water;

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and the cork being removed, the bottle was broken in the water, by means of a pair of pinchers. A part of the cold water was taken away, and hot water was added to fill the vessel to the lip, and to raise the temperature to 80°.

An elastic fluid soon issued from the wetted phosphuret, and flashed at the surface where it met the air. When the troubled liquor had acquired greater tenacity than that of water, bubbles formed and swelled on the surface, and burst successively with explosive flashes. From each brilliant and distinct flash arose a thick ring of dense vapour as white as snow, bounding an open circular area, two or three inches in diameter. These rings widened gradually and regularly as they mounted in quiescent air, until they included areas of one or two feet in diameter; in ascending to the height of 10 or 15 feet, they maintained their horizontal position, until they were dispersed by spreading.

The following explanation was offered.

Phosphorus, like other combustible bodies, attracts oxygen with sufficient force to decompose water, and to detach the hydrogen; and due incalescence is all that is necessary to pro-

promote the oxygenation of phoſphorus by water.

This incaleſcence is cauſed by the flaking lime; and whilſt the oxygen of water combines with phoſphorus, the hydrogen which attracts phoſphorus and Caloric, paſſes off with theſe in the form of phoſphorated hydrogen gas.

This gas preſents the phoſphorus in a ſtate of extreme diviſion to the air, which conſequently inflames the phoſphorus, and alſo the hydrogen gas expoſed to this flame, as faſt as the ſwoln bubbles burſt from the water.

The product of the combuſtion is flocculent phoſphoric acid and aqueous vapour, thrown by the eccentric impulſe of the exploſion, into the form above deſcribed and buoyed in the air, until the ring is cooled or diſſipated.

How far Electric matter might have contributed to this phenomenon of the rings, was not examined.

Theſe experiments were repreſented as additional proofs of the notion formerly expreſſed, in regard to the nature of Caloric and Light, and to the oxygen as a common principle of all acids and oxyds.

MINUTES

OF THE

SEVENTEENTH MEETING,

ON

SATURDAY, May 31, 1794.

Decompoſition of Water, Metallic Oxyds, and Acids.

IT was the general opinion in reſpect to the experiments announced for the abſtraction of oxygen from metallic oxyds and water and acids, that the moſt impreſſive and durable ought to be made, previous to thoſe which might be fitter for accurate menſurations and a ſmaller party.

The firſt experiment for decompoſing water, differed from that deſcribed by LAVOISIER, page 140 and 481, in the following particulars only.

Inſtead of 274 grains of plate iron rolled up

up ſpirally and placed in a glaſs tube, 3 oz. 10 dt. = 1680 grains of the fineſt harpſichord wire, were looſely wound into balls and rammed into a muſquet barrel, from which the part which receives the breach-pin was cut off at the touch-hole.

The reverberatory furnace, acroſs the bed of which the barrel was placed, had the advantage of heating the middle part of the barrel, where it was charged with iron wire, to the length of 22 inches; whilſt the ends which projected out of the furnace, were kept cool by a current of air.

The glaſs retort which was ſmall, was filled to the helm with three ounces of water, and when luted into the thick end of the barrel, was heated by an Argand lamp, inſtead of a ſtove; and the ſtand on which the lamp ſtood, could be raiſed or lowered by means of a ſcrew, to regulate the evaporation of the water.

The ſpiral worm and refrigeratory into which the ſmaller end of the barrel was luted, was not at all affected by the heat of the furnace, and was kept at a low temperature during the operation, by throwing ice into the water, to prevent the current of hydrogen gas from wafting away any aqueous vapour

which might eſcape the intended decom-poſition.

The quick condenſation of ſuch vapour in the worm, was alſo promoted, by making the mercury through which the hydrogen gas was forced, to preſs on it with a column of one inch.

When the muſket barrel was heated to incandeſcence, and the water in the ſmall retort was made to boil gently; the hydrogen gas which iſſued, was received in quart bottles ſucceſſively applied; until the immenſe bulk and experienced purity of it, rendered the further menſuration inconvenient, and unneceſſary for the preſent purpoſes.

A part of the mercury being then withdrawn, the gas was paſſed off more quickly through a two inch column of water, into a ſmall glaſs funnel inverted, which delivered it into the air. After the gas had paſſed for about an hour, from the commencement of the operation, it was inflamed at the tube of the funnel, to prevent it from being offenſive, whilſt the ſociety were detained by other experiments.

In this experiment, a circumſtance which ſeemed to have eſcaped Mr. LAVOISIER's attention,

tention, was duly considered. A worm of this size must retain a considerable quantity of water adhering to its internal surface. The worm was therefore wetted, before the muzzle of the musket barrel was cemented to it; and it was drained for twelve hours before the recipient was cemented to the beak of it. The intention was that the like time should be allowed for draining the worm, after the experiment; and that the adhesion of water to the worm, should not prevent the true mensuration of that which might pass unaltered through the wire.

As the vessels were set for 24 hours before the experiment was commenced in the presence of the Society, some members observed a few drops of water which had drained from the worm into the recipient, in the last 12 hours; but the cause being explained, they presently perceived that this availed nothing against the experiment, and that the addition of a single drop of water could easily be discovered in so small a quantity collected in a glass recipient of this figure and size.

All those who were attentive to these circumstances, saw that the hydrogen gas issued to an immense bulk during a full hour, before

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any water trickled from the worm ; and perceived that no water eſcaped undecompoſed, whilſt the wire preſented clean ſurfaces to the aqueous vapour.

But when the iron wire might well be expected to be ſuperficially and partially oxydated ; the part of the aqueous vapour which eſcaped through it along with the hydrogen gas, began to ſhew itſelf condenſed in drops ſlowly trickling from the beak of the worm ; and as the oxydation went deeper into the wire, and defended the metal better from the vapour, the quantity of condenſed water was greater, relatively to that of the hydrogen gas which accompanied it.

When the emiſſion of hydrogen gas had almoſt ceaſed, although the water in the retort continued to boil, the fire and the lamp were withdrawn. The water in the recipient, after the worm had drained for 12 hours, being about half an ounce, was added to that remaining in the retort, and weighed with it.

Thus it appeared that the quantity of water expended in the oxydation of the iron and production of hydrogen gas, was 1 oz. 6 dt. 16 gr. = 640 gr.

The wire, which was oxydated, encreaſed in thick-

thicknefs and brittle, and in all refpects like burnt iron, was broken out of the barrel with a rammer. A little of it adhered in fome places, and could not be removed without hammering the barrel; in which cafe a fmall quantity of the burnt furface of the latter might have been beaten off. But as the burnt wire was eafily diftinguifhable from the fcales, it was ftated that the weight of the oxyd exceeded that of the wire by 1 oz, 1 dt. 17.5. gr.

As the internal furface of the barrel was oxydated to the length of twenty-two inches; and 27 grains of water may well be allowed for this oxydation; the refult of this experiment correfponds with that of LAVOISIER, in regard to the quantity of the oxygen of water, and the quantity which iron takes from the water, during the oxydation.

The experimenter having fhewn a barrel much longer and larger than the foregoing, ventured to promife that with a charge of eight or ten ounces of very fine wire, an ounce of water fhould be fo compleatly decompofed in it, that no aqueous vapour fhould efcape into the worm. In this cafe it was propofed that the decompofition fhould be

effected more slowly; and that the whole of the hydrogen gas should be measured, to shew directly how much hydrogen is contained in an ounce of water.

In the manner of the last experiment, charcoal powder was used instead of Iron wire. But as the charcoal could not be expected to preserve its position by elasticity, and as the aqueous vapour was likely to pass over it, after a short time, instead of passing through it, the charge was made in the following manner. A pellet of clay was fixed by two opposite rammers in the musket barrel last used, at the place where the charge of charcoal was to commence, like the charge of Iron wire.

The side of the barrel which was to be lowest, when placed horizontally in the reverberatory furnace, was marked with a file, and a hole was made through the pellet of clay on this side, by the pointed end of the rammer.

A few fragments of charcoal which could not

not paſs through this hole, being thrown in; charcoal powder was added to make a charge of two inches. Over this another pellet of clay was rammed and pierced in the deſcribed direction; and then Charcoal powder confined by intermediate pellets of clay, was introduced to make a charge of 22 inches in length. This was compleatly dried.

Thus any aqueous vapour paſſing through the barrel, muſt be compelled to paſs through the maſs of each ſucceſſive charge of charcoal, ſo long as any of it remained at the loweſt ſide of the barrel to cover the perforations of the pellets.

The barrel having been previouſly oxydated on the internal ſurface, was as fit for this experiment, as a tube of glaſs or Potters ware; becauſe the heat at which charcoal can decompoſe water, is not nearly ſo great as that which is neceſſary for the reduction of oxydated Iron to the metallic ſtate, by carbonaceous bodies; and the oxyd of Iron which lined the barrel, was already a ſpecies of glaſs which could not be melted in the experiment.

The water which was puſhed in vapour through the charcoal for more than an hour,

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was all decompoſed; but afterwards ſome vapour eſcaped and was condenſed in the worm, for the reaſons formerly mentioned; and eſpecially when the vapour was preſſed through with too much velocity: the whole quantity of charcoal being only 1 oz. 7 dt.

The products of the decompoſed water and conſumed charcoal, were Carbonic acid gas and hydrogen gas; the bulk of the former being to that of the latter generally as 18 to 1.

The experiment was continued for three hours, and was highly impreſſive; and every ſubſequent attention to the expenditure of about 24 dt. of water, and 8 + dt. of charcoal, tended to ſhew that the concluſions expreſſed by LAVOISIER, page 137, are generally true in regard to the decompoſition of water by Charcoal; and to the conſtitution of Carbonic acid gas; although he could not have arrived at ſuch concluſions and menſurations without having varied his experiments beyond all that he has deſcribed.

In the converſations which followed, the phenomena of exploſions from water thrown on melted metals, or on fuel heated to incandeſcence; and of the hydrogen gas which

iſſues

iſſues when a glowing bar of Iron is plunged in water, or when ſulphurets of metals or metallic filings are covered with water and long expoſed to the action of Light, or when metals are diſſolved in weak ſulphuric acid; were noticed and explained.

A veſſel ſimilar to the Zinc pot of the manufacturers, and placed in their manner in a ſmall Zinc furnace, was charged with twelve pounds of oxyd of Zinc, and two pounds of Charcoal finely powdered.

A ſtrong fire being applied for eight hours, the oxygen of the oxyd was all expended in the formation of Carbonic acid gas with the Carbo, and the Zinc was diſtilled through the bottom of the Zinc pot into water.

Sixteen ounces of the oxyd of Lead, called Litharge, were mixed with half an ounce of Charcoal powder, and duly heated in a retort which delivered the gaſſeous products through a ſmall quantity of water. The oxygen of the Litharge formed Carbonic acid gas with

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the Carbo, of which ſcarcely any remained, and the Lead in this oxyd appeared to be in the proportion of 85 parts in 100.

It was obſerved that this and divers other oxyds prepared in reverberatory furnaces, or by expoſure to carbonic acid gas and air, contain ſome Carbonic acid gas, and require the leſs carbo for the reduction of them.

Sixteen ounces of Sulphat of Soda dried by fuſion, were mixed with 2½ ounces of powdered Charcoal; and the heat being applied from above downwards, to moderate the intumeſcence, they were ſlowly fuſed, until Sulphuret of Soda was formed, in conſequence of the eſcape of the oxygen of the Sulphat in combination with the Carbo.

The Carbonic acid carried off a little ſulphur; but not ſo much as to prevent the chief part of the ſulphuret from returning to the ſtate of Sulphat of Soda, or glaubers ſalt, when it had been long expoſed in a moiſt ſtate to the air; from which it reſumed the oxygen expelled in the foregoing proceſs.

The violent cauſticity of the Sulphuret of Soda, and the ſaponaceous quality which it imparts

imparts to water, were mentioned as having caufed great difappointments and loffes to Artifts who imagined that the cheap neutral falt was thus convertible, by charcoal, into a valuable alkaline fubftance fimilar to Barilla.

Various other methods of decompofing fulphuric acid were mentioned; and the decompofitions of Nitrous acid and Nitric acid by combuftible fubftances, and generally without the aid of ignition, were announced for the enfuing meeting.

MINUTES

OF THE

EIGHTEENTH MEETING,

ON

SATURDAY, June 7, 1794.

An Attempt to explain the Agency of a Spark, or of Ignition, in the Ascension of Combustible Bodies.

Oxygenations and Combustions by Acids.

Experiments indicating the Identity of the Matter of Caloric and Light.

A MIXTURE consisting of two measures of hydrogen gas and one of oxygen gas, and which had been long kept in a state of compression, without having undergone any alteration; was now compressed again by a ten inch

inch column of mercury: and it was affirmed, from experiments made on ſmaller quantities, that no condenſing force hitherto applied, could deſtroy the elaſticity of the mixed gaſſes, or compel the baſes to unite and exclude the Caloric.

Small quantities of ſuch mixtures were then inflamed and exploded, by a flint ſpark, by a ſmall bit of lighted tinder, and by an electrical ſpark. A ſtream of hydrogen gas iſſuing from iron and diluted ſulphuric acid, through a narrow tube, into the air, was next inflamed, and ſuffered to burn at the extremity of the tube for an hour, ſhewing that the aſcenſion of any ſmall part of a mixture of hydrogen gas and oxygen gas, is ſufficient for the deflagration of any quantity of them.

As the gaſſes thus inflamed, loſt their elaſticity together with the Caloric, whilſt their baſes united to form water, the following obſervations were made.

Theſe phenomena may ſeem to be incompatible with the notions of Caloric ſo often inculcated. If it were true that the elaſticity of the gaſſes is maintained by Caloric only, and that the ſpark acts on them by Caloric

only, the ſpark ought to increaſe the elaſticity, inſtead of deſtroying it. For we are taught by general experience to expect encreaſed effects from encreaſed powers, inſtead of effects ſo different in their nature as theſe appear.

This expectation is moreover warranted by direct experiments of which the following is an inſtance.

The mixed gaſſes, when heated in a new and clean glaſs retort, expand with forces augmenting with the heat; and when permitted to expand freely, may be heated until the bottom of the retort becomes almoſt red; and all this may be done, without any accenſion of the gaſſes, or any decompoſition of them.

In anſwer to theſe objections, the following expoſition was propoſed.

In the mixture of gaſſes, and in portions much ſmaller than the volume of a ſpark; particles of hydrogen and of oxygen charged with their reſpective repellent atmoſpheres, intercede each other, and form a minute ſyſtem differing from the whole in nothing but volume or quantity.

Let *a*, Plate III, repreſent a particle of hydrogen:

drogen: and let the concentric circles *b c d*, represent different altitudes of the small atmosphere of Caloric which is engaged round *a*. As the densities of such atmospheres decrease as the distances from the central particles increase, and the present exposition does not require that the ratio of this decrease should be expressed; Let the distances of the atoms of Caloric from each other at the altitude *b*, be as the distances between *a* and *b*; and at the altitude *c*, as the relative distance between *b* and *c*; and at the altitude *d*, as the relative distance *c d*.

Let *e f g h* in like manner represent a particle of oxygen with its atmosphere of Caloric.

In a system of such particles carrying their respective atmospheres and carried by them, the attractive central particles such as *a* and *e*, cannot approach to unite, without excluding a part of the Caloric which intercedes them, which exclusion the attraction of Caloric resists; or without doubling the densities of the atmospheres at every altitude, which increase of density the repellent nature of Caloric resists. For in the first stage of approximation of *a* to *e*, *d* will meet *h*, and the

the density at *d* will be doubled; in the next stage of approximation *c* will meet *g*, and the density at *c* will be doubled; and in the closer approximation the density of the Caloric at *b* when it meets *f* will be doubled.

To these approximations of the central particles, and to the concomitant augmentations of the density of the intermediate matter, the Caloric resists with forces encreasing with its density, and with the nearer approach of the central particles towards each other, and therefore the expansive force of a mixed fluid thus constituted, is greater as the density is encreased by pressure; and as the quantity of Caloric is increased with the augmentation of temperature.

The insuperable resistance of these elastic fluids, to mechanical forces tending to the aggregation of their central particles, and to the expulsion of their Caloric, shews at once the repulsive nature of the parts of Caloric relatively to each other, and the powerful attraction by which the particles maintain their respective atmospheres, and are retained in them.

As it is not necessary now to repeat what has been advanced in the former minutes, concerning

cerning the condition of the Caloric of theſe gaſſes, it is ſufficient to obſerve that the phenomena expreſſed in the laſt paragraph, cannot, conſiſtently with any known property of matter or law of nature, be produced by Caloric of uniform denſity.

If the particles *a* and *e* were placed in Caloric of equal denſity in the whole ſpace between *i* and *k*, this fluid would act equally on them in all directions; and the particles *a e*, being equally drawn or impelled on all ſides, would meet no impediment from the Caloric, in obeying the attractive power which tends to the approximation and union of them: and ſuch uniform denſity of the Caloric around them, would, in reſpect to their reciprocal attractions, be equivalent to a total privation of it.

We accordingly find that when a minute portion of the gaſſeous mixture is ſuddenly enveloped by the denſer Caloric of a ſpark, the attractive baſes inſtantly unite.

To illuſtrate this agency of the ſpark, let the Plates III. and IV. be held up between the light and the eye; and let the diſtance between any two of the concentric circles Pl. IV. which will appear through the paper, repreſent the rela-

tive diſtances between the atoms of Caloric which a ſpark diffuſes through the whole ſpace between *i* and *k*, Plate III. The central particles *a e* will now appear in the Calorific fluid, whoſe denſity in the whole ſphere *i k* equals or exceeds that of the former atmoſpheres in the denſeſt parts between *a b* and *e f*.

The atmoſpheres being now blended and confounded in the Calorific fluid; the particles *a e*, preſſed or drawn on all ſides by contrary and equal powers of this fluid, neceſſarily obey the attractive forces which ever tend to the union of them.

The Caloric excluded from the uniting faces of ſuch particles, being inſtantly added to that of the ſpark, extends its agency to other portions of the gaſſes; and thus a ſingle ſpark ſerves to inflame any quantity of them, and they are expended in the formation of water, and the evolution of Caloric and Light.

Nothing beſides the mutual repulſions of the parts of the liberated Caloric, ſeems neceſſary to this Evolution, and to the projection of ſome parts with the velocity of Light, whilſt the motion of others is retarded or ſtifled in their oppoſite courſes.

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The foregoing explanation was given of the agency of a ſpark or of partial ignition, towards the inflammation of divers ſolid fluid and vaporous bodies in oxygen gas or in air, in a manner too obvious to claim any recital in theſe minutes.

The agency of a ſpark or of partial ignition, in mixtures of Nitric and combuſtible bodies, and in gunpowder eſpecially, was next conſidered.

Laſtly experiments were announced for the next meeting; in which it ſhould appear, that certain bodies may be made to hold oxygen and combuſtible matter combined with Caloric, nearly in a ſtate of equilibrium between the forces tending to maintain their aggregation, and thoſe tending to the deflagration or exploſion of them: that ſome bodies of this kind ſhould require nothing more than ſlight incaleſcence or friction or percuſſion, to cauſe an exploſion of them: and that Fulminating ſilver ſhould explode by the touch of a feather.

It was obſerved that theſe uncommon phenomena might eaſily be explained on the grounds lately deſcribed; and not on any other that have ever been mentioned.

This ſketch was offered to the ſociety with due diffidence, and for the avowed purpoſe of exciting the attention of the members who had better talents and more time than the Experimenter, for the vigorous proſecution of the moſt intereſting ſubjects of modern Chemiſtry; namely Caloric and Light, with which the knowledge of the Electrical fluid is cloſely connected.

Nitrous acid having been compoſed at former meetings by adding oxygen gas to Nitrous gas, and having been decompoſed by mercury, to which it imparted the oxygen; other experiments were now mentioned, on which the following ſtatement correſponding with that of LAVOISIER, page 124, was founded.

"About $\frac{3}{4}$ of Nitrous acid, and about $\frac{4}{5}$ of "Nitric acid conſiſt of oxygen. And as "the experiments of Mr. KIRWAN, an "excellent philoſopher, ſhew that 100 parts "of Nitre contain thirty of Nitrous acid; "22.5 of oxygen are contained in 100 parts "of this ſalt."

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On theſe grounds the agency of Nitrous acid and nitrous ſalts in the oxygenation and combuſtion of bodies, was eaſily explained, whilſt the following experiments preſented the phenomena.

An ounce of ſulphur was gradually oxygenated in the courſe of ten days, and formed into ſulphuric acid, by adding the powdered ſulphur in ſucceſſive portions to ſix ounces of Nitric acid, and augmenting the temperature, until the Nitrous gas and ſuperfluous Nitrous acid were expelled. In the courſe of ſuch experiments it was found that when the ſulphur was haſtily added to the Nitric or Nitrous acid, the Caloric ſuddenly extricated, boiled the whole mixture out of the veſſel.

Sugar was oxygenated by Nitrous acid, in the manner of SCHEELE and BERGMAN, and formed into white cryſtalline acid of Sugar; and a better method of preparing the acid of Sugar was ſhewn. This conſiſted in the uſe of leſs acid, in a very tall veſſel acceſſible to air.

air. The Nitrous gas, instead of being wasted, formed Nitrous acid with the oxygen of the air, and returned into the mixture of acid and Sugar. The like expedient was recommended, for the solution of metals in Nitrous acid.

The rapid oxygenation and combustion of oils by Nitrous acid, was exemplified, by the addition of this acid in successive drops to oil of Turpentine. As the second or third drop of the acid inflamed the oil, with an explosive report, it was manifest that the addition of a greater quantity would be attended with danger.

This experiment shewed the great quantity of Caloric combined in the several ingredients, and extricated during the union of the oxygen with the combustible body: and it was observed that if the products had been saved, they would be found to consist of Carbonic acid gas and water produced from the Carbo and hydrogen of the oil and the oxygen of the acid, and of the azotic and Nitrous gas resulting from the decomposition of the Nitrous acid,

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The uſe of a ſmall quantity of ſulphuric acid in the nitrous, to accelerate the inflammation of the oil, being mentioned; Dr. LATHAM added an inſtruction "to place the oil "in a ſhallow veſſel, and to drop the acid on "it gradually in the ſame place, and near "the circumference."

Phoſphorus was ſlowly converted into phoſphoric acid, by Nitrous acid; the Nitrous baſe eſcaping as faſt as the oxygen combined with the phoſphorus.

Experiments were alſo made with pyrophori and Nitrous acid, and Nitric acid; to ſhew the ſtrict analogy of the oxygenations and combuſtions in nitrous acid, Nitric vapour, and atmoſpheric air.

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Previous to the experiments for ſhewing the identity of the matter of Caloric and Light, it was ſaid that the approaching termination of the ſeſſion, prevented the Experimenter from attempting any addition to thoſe which he had formerly deviſed, and which ſhould now be preſented with the mere hope that the ſociety would ſuggeſt others more ſatisfactory and deciſive.

Whilſt the experiments which are preſently to be deſcribed, were advancing to the ſtate fitteſt for obſervation, remarks were made on divers optical phenomena to the following effect.

1ſt. Theſe phenomena ſhew that Light conſiſts of minute parts, projected in ſucceſſion from luminous bodies, and obedient to the laws of motion.

2d. Rays of Light, which pervade diaphanous media without heating them, or which rebound from reflecting media without heating them, produce incaleſcence in opaque bodies which ſtifle the projectile motion; and Light thus ſtopped has all the properties of Caloric.

3d. Rays of Light, bent by refracting or reflecting media, to a common focus, and there

there ſtopped by any body, produce heat, nearly in proportion to the quantity of coincident Light that is ſtopped in a given area of the focal place.

The temperatures being equal at equal diſtances from the focal area at which the rays croſs each other, ſhew that the ſame matter which illuminates without heating, has all the properties of intenſe fire or denſe Caloric whenever it is accumulated and retarded.

4th. The phenomena of combuſtions ſhew that the Light is, cæteris paribus, proportionate to the velocity with which the Caloric is emitted; and that there is no illumination from bodies which, during the oxygenation of them, emit the Caloric either ſlowly, or in circumſtances in which manifeſt impediments prevent the projection of it with the velocity neceſſary to the conſtitution of Light.

5th. The brilliancy and apparent quantity of the Light emitted in combuſtions, is greateſt from bodies which yield little or nothing of the gaſſeous kind to detain a part of the emitted Caloric; as in the combuſtion of Iron Zinc and phoſphorus: whilſt the Light from

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combuſtions of the oppoſite deſcription, is weaker and apparently leſs in quantity, in proportion to the quantity of gaſſeous matter capable of engaging the Caloric.

6th. The effects of Light on vegetation, on Chemical bodies, and in a variety of inſtances which cannot be expreſſed in a few words, all ſeem to correſpond with theſe notions of the matter and motion of Light.

In reſpect to the different coloured rays of Light which iſſue from flaming bodies, or appear in the priſmatic ſpectra; and the different refrangibility of the rays of different colours; it was propoſed that theſe phenomena ſhould be exhibited in the ſeſſion of the next year: there being more reaſon to expect, from the united efforts of the members, that theſe things ſhould be explained conſiſtently with the laws of motion, and with the nature of the medium which ſubſiſts at every refracting ſurface; than to admit that there are as many different kinds of Light, as there are kinds of rays differing in refrangibility, and yet unalterable in Colour.

It was finally obſerved that the gentlemen who were moſt converſant in optical experiments and practice, have always appeared to

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be moſt ſtrongly impreſſed by the following experiments and inferences.

EXPERIMENT I.

The body of a ſmall long necked matraſs was charged to the middle with Nitrous acid, and was looſely ſtopped with a conical glaſs ſtopper. The acid being heated until the Nitrous vapour had iſſued for a much longer time than was neceſſary for expelling all the air from the neck of the veſſel; a ſmall cylindrical meaſure filled with half a dram of Pyrophorus, was quickly inverted into the neck of the matraſs, to deliver the pyrophorus into the vapour and acid.

The pyrophorus employed was made with Alum and flour, in the manner formerly deſcribed; except that it was not ſo long heated. It was therefore tardy in the accenſion by air.

In the inſtant of the delivery of the Pyrophorus, and whilſt it fell through the Nitrous vapour, the finer powder burned and emitted Light; but the coarſer grains which eſcaped the action of the acid vapour, by

their quicker deſcent and cloſer texture, cauſed a violent commotion of it, and heated it during the oxygenation, but ſhewed no Light.

Whilſt Nitrous vapour and Nitrous gas iſſued quickly, freſh charges of Pyrophorus were repeatedly introduced, with the ſame events of illumination in the vapour, and incaleſcence only, in the acid.

The matter of the acid and of the vapour being preciſely the ſame in kind, and the temperatures being equal; and the pyrophorus being rapidly oxygenated in the acid liquor, as well as in the vapour; there was no reaſon to ſuppoſe that the matter of Caloric or Light emitted in the acid, was different from that which was emitted in the vapour. It rather ſeemed that the motion which might give the character of Light to the evolved matter of Caloric, was ſtifled in the denſe and heavy acid; whilſt the diſtances of the particles of the vapour, permitted the free tranſmiſſion of a part of this matter with the velocity of Light.

EXPERIMENT II.

An experiment which was too offenſive and dangerous to be made in the preſence of the Socieiy, was related as follows.

A wide mouthed ounce bottle filled with pyrophorus, and containing azotic gas only, in the interſtices of the pyrophorus, was placed with the mouth inverted in a glaſs tumbler; and Nitrous acid was poured into the tumbler to exclude the air from the pyrophorus.

After ſome of the azotic gas had been expelled, along with ſome Nitrous gas produced from the part of the pyrophorus and acid which firſt touched each other; more of the acid was added to the height of about an inch in the tumbler.

In this ſtate, the interſtices of the pyrophorus being filled with Nitrous gas and azotic gas, no acid vapour could ſpread into them, whilſt the pyrophorus gradually imbibed the acid. Notwithſtanding the incaleſcence, nothing luminous appeared in the bottle.

The entry of the acid to the pyrophorus,

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was occaſionally promoted, by inclining the bottle ſo as to expel ſome of the contained gas. But although the incaleſcence was thus frequently renewed, no viſible Light iſſued from the pyrophorus thus ſteeped in the acid. But when portions of the pyrophorus eſcaped quickly through the acid, in conſequence of this inclination of the bottle, and were carried by the efferveſcence above the acid into the column of Nitrous vapour which filled the tumbler, they ſparkled briſkly and emitted Light.

EXPERIMENT III.

Three pieces of rectified phoſphorus weighing fifteen grains, were dropped into a ſmall long necked glaſs matraſs containing two ounces of Nitrous acid.

After the ſurfaces became oxygenated and incruſted with dry phoſphoric acid, the bubbles of Nitrous gas, which iſſued at firſt, gradually diſappeared; and the phoſphorus remained quieſcent at the bottom of the veſſel.

It was related from experience, that phoſphorus may be oxygenated ſooner in a weaker acid than this; becauſe the water diſſolves the acid incruſtation.

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To break the pellicle which formed on the phoſphorus in the acid, both were heated until the phoſphorus became ſoft.

Now the oxygen of the acid combined gradually with the phoſphorus, and the liberated nitrous gas which iſſued quickly, agitated the acid and the phoſphorus briſkly.

When the Caloric emitted during the oxygenation, had increaſed the temperature of the acid, the matraſs was removed into cold ſand. The incaleſcence and effervеſcence neverthelеſs continued; and Nitrous gas mixed with Nitrous vapour iſſued briſkly from the neck of the matraſs.

Although ſuch maſſes of phoſphorus, when expoſed to air, give light which is viſible in darkened places; and continue to afford ſuch Light for weeks, without being oxygenated ſo much as theſe pieces were in a few minutes in the Nitrous acid; nothing Luminous appeared in the acid, or in the vapour above it, or in the air around the vapour.

The veſſel containing the acid and ſoftened phoſphorus was quickly cooled, until the phoſphorus became hard and the oxygenation ceaſed.

The foregoing proceſs was afterwards re-

newed and continued, until the whole of the Phoſphorus became phoſphoric acid, eaſily ſeparable from the reſiduary Nitrous acid by evaporation; without ſhewing any luminous appearance.

EXPERIMENT IV.

The ſame quantities of phoſphorus and Nitrous acid were made to act on each other in the manner of the laſt experiment; excepting that the quick efferveſcence was not checked, but was permitted to proceed until the phoſphorus was buoyed above the acid into the nitrous vapour, which poured forth from the veſſel.

Every part of the phoſphorus, which emerged from the acid, into the acid vapour, gave a bright light, ſimilar to that of phoſphorus burning in air; whilſt thoſe parts which remained immerſed in the acid, kept up the commotion and heat, without any lucid appearance in the Diaphanous acid.

As the oxygenation of the phoſphorus was effected in theſe experiments, as well in the acid, as in the vapour of the ſame acid; and

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there was no reaſon to doubt that the combinations of oxygen and phoſphorus, and the extrications of Caloric, were the ſame in both caſes; it was inferred that the ſame Calorific matter which was wholly expended in the firſt experiment in heating and evaporating the mixture, was in the ſecond experiment expended to a certain part of it and projected in the form of Light.

" As luminous matter is emitted during
" the oxygenation of phoſphorus in air, or
" in nitrous vapour, whoſe principles are of
" the ſame kind as thoſe of air, it is ſcarcely
" to be imagined that the ſame kind of mat-
" ter is not alſo emitted during the oxygena-
" tion of phoſphorus in the nitrous acid, the
" principles of which are not different from
" thoſe of the vapour.

" If the ſame kind of matter be capable
" of conſtituting Light without cauſing any
" ſenſible heat or acting as Caloric, and alſo
" capable of acting as Caloric, without
" cauſing any ſenſible illumination or acting
" as Light; it is highly probable that the
" mere matter of Caloric and Light is the
" ſame; and that they differ only in the
" motion."

Many phenomena of this kind being briefly deſcribed, this general inference was hazarded.

"During the extrication of Caloric in a "denſe fluid, ſuch as Nitrous acid, the in-"ertia of the oppoſed parts of the denſe "fluid, reſiſts the projectile power, and the "whole of the Caloric is expended in aug-"menting the temperature."

"But when the Caloric is quickly extricated in a gaſſeous fluid or vapour, the repellent atmoſpheres of which preſent free ſpaces for the paſſage of projected particles or atoms of Caloric; thoſe which are projected with the velocity of Light, meet no impediment that is ſufficient to prevent their perſiſting in the motion proper to Light."

EXPERIMENT V.

This, which afforded the inferences above mentioned, was made in the following manner.

Four ounces of Nitrous acid were introduced into a matraſs like that lately employed, and one ounce of the ſtrongeſt marine acid was quickly added; in order to make a

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menſtruum in which antimony might be quickly diſſolved and oxygenated.

About ten grains of regulus of antimony, in coarſe powder ſifted from the fine, were dropped into the mixed acids; and the quick ſolution, efferveſcence and incaleſcence were duly noticed, together with the oxydation of the antimony; but there was no appearance of Light.

Whilſt the acid vapour iſſued briſkly from the neck of the matraſs, after having expelled all the air; powdered regulus of antimony, conſiſting of larger and ſmaller grains was uſed. The large grains being intended to fall unaltered into the acid, and to generate Caloric and acid vapour; the ſmall grains to fall more ſlowly and to be oxygenated in the vapour.

Whilſt the former diſſolved with ſtrong efferveſcence and incaleſcence without any viſible illumination, the latter ſhewed a luminous combuſtion in all parts of the veſſel which were occupied with acid vapour only. This appearance was renewed twenty times, by as many additions of the antimony; but no light was viſible, in any place, excepting that of the acid vapour.

In

In all ſuch applications of Nitrous acid, it is to be obſerved, that the firſt portions of Caloric extricated during the chemical union, produce the incaleſcence neceſſary for the accenſion; that the ſubſequent portions iſſue more rapidly, during the combuſtion; and that the quantity of Caloric thus evolved from ſuch denſe or ſolid bodies, ſhews that it ſubſiſted in them in a ſtate of combination.

Finally it was ſaid of the fulminating compounds intended for the next meeting; that the Calorific matter emitted at the inſtant of the exploſion, ſeems to be almoſt wholly expended in a momentary illumination; for when ſuch exploſions happened accidentally in the experimenter's hand, he felt it beaten or bruiſed, but not conſiderably heated,

MINUTES

OF THE

NINETEENTH MEETING,

ON

SATURDAY, June 14, 1794.

Experiments on Combuſtible and Exploſive Compounds.

Deſultory Experiments and Subjects.

THE explanation offered in the courſe of the following experiments, were mere applications of the foregoing doctrines to the ſubjects under conſideration. They are therefore omitted in this haſty ſketch of the buſineſs of this meeting.

1ſt. The introductory experiments ſhewed that pieces of charcoal may be thrown into Nitre fuſed to fluidity, and approaching to a red heat, and may be kept in this ſituation

for

for many minutes if not for any longer time, without ſhewing any appearance of combuſtion.

2d. That either the Nitre or the Charcoal muſt be heated to redneſs, at the points of contact at leaſt, before the combuſtion commences.

3d. That the Caloric emitted during the accenſion of any ſmall part of a mixture of 3.5 parts of Nitre and one of Charcoal, both being finely powdered and dried, is ſufficient for the deflagration and conſumption of any quantity of them.

4th. That the heat or ignition neceſſary for the accenſion of mixtures of ſulphur and Nitre, is leſs than the foregoing.

Nitre and Charcoal were deflagrated in ſuch a manner as to ſhew the quantities of Carbonic acid gas and Azotic gas produced during the combuſtion, and alſo the alkaline reſidue of the Nitre, and the Caloric or matter of Light, which theſe bodies held in a ſtate of combination.

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The compoſition of gunpowder being ſhewn; the uſe of each ingredient towards facilitating the accenſion, or accelerating the combuſtion, or augmenting the quantity of gaſſeous matter producible during the combuſtion, was explained. And in ſpecimens of gunpowder which differed only in the degree of mechanical comminution and mixture, it was ſhewn that the velocity of the exploſive deflagration depended as much on due mixture, as on the proportions of the materials.

It was obſerved that the Caloric which theſe materials ſeverally held in a ſtate of combination, was ſufficient to give the gaſſeous form to more than one third of the maſs, and alſo redundant caloric appearing and acting as Fire and Light.

As projectiles are not inſtantly permeable either by Caloric or Light; it was repreſented that the liberated Caloric of theſe deflagrations, co-operates with that of the elaſtic gaſſes, towards the propulſion of projectiles by gunpowder.

Similar obſervations were made on the materials of Fulminating powder compoſed of three parts of Nitre, two of prepared Kali of the London College and one of Sulphur; and the ſucceſſive and ſlow combuſtions of mechanical mixtures of theſe ingredients, were experimentally ſhewn.

A dram of this powder, being placed in the bowl of an Iron ladle, was gradually heated until the ſulphur was melted into the alkaline ſalt, and the ſulphuret thus formed was chemically blended with the Nitre.

The fuſed maſs was permitted to cool for a while; and whilſt it was yet ſoft, it was taken out of the Ladle by means of a ſpathula, and ſaved in a dry and warm bottle.

When it was cold a flint ſpark inflamed it; and it burned like gunpowder, but with greater velocity and report, by reaſon, it was ſaid, of the more perfect mixture of the oxygenous with the ſulphureous matter.

It was obſerved that a ſimilar compound may be made, by fuſing ſulphuret of Potaſh with Nitre; and that any ſuch compound may be cooled, and fuſed again repeatedly, without inflammation or exploſion; provided no more heat be applied than is neceſſary

ceſſary to the fuſion. And although the Caloric of a ſpark be much leſs in quantity than the caloric neceſſary for the fuſion of a large maſs of ſuch matter, the denſer Caloric of a ſpark never fails to explode the whole, for the reaſons aſſigned in the minutes of the laſt meeting.

When a ſpark is applied to a cold maſs of this kind, the fire extricated from the ſmall portion firſt inflamed, operates upon the next, and this upon more, until the whole is decompoſed; and thus the combuſtion, though quick, appears in a long train, to be manifeſtly ſucceſſive, as in a train of gunpowder; each portion of which muſt be impreſſed with Caloric of determinate denſity, before the combuſtion can be commenced in it.

On this ground an explanation was given of the weak report and effects of gunpowder, or of fuſed and cooled fulminating powder inflamed in the open air; in compariſon with the loud report and forcible effects of the ſame bodies when fired in cloſe veſſels or in the Chamber of a gun. And theſe things were conſidered with a view to the ſolution of the following phenomena.

A dram of the foregoing mixture of Nitre

alkali and ſulphur, was gradually melted in an Iron ladle, and was then removed from the heat. After it had ſtood long enough to ſhew that it would rather cool than explode; a ſmall quantity of Charcoal powder heated to redneſs, was dropped from the height of ſix feet, ſo that a ſpark or two might fall into the melted maſs.

On the touch of the firſt ſpark the whole exploded inſtantaneouſly with a loud and ſhocking report, and with a flaſh ſo momentary as to make but little impreſſion on the ſight.

Fulminating powder being in the next place employed in the uſual manner; it appeared that when the fuſed maſs was heated a little more than was neceſſary to effect the fuſion; the whole exploded as inſtantaneouſly and loudly as that which was fired with the ſpark.

In all theſe caſes the accenſion appeared to depend entirely on the denſity of the ſuperadded Caloric, and the agency deſcribed in the minutes of the laſt meeting.

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The best process for the preparation of fulminating gold being shewn; the principles furnished by the acids during the solution of the gold, and those furnished by the ammoniac during the precipitation; and the order necessary in the application of them, were considered; and divers experiments were related, by which it appeared, that this substance consists of oxygen azot and hydrogen, severally combined with Caloric, and severally attached to the gold as a common base.

Twelve grains of this fulminating gold being placed in a conical heap on a thin plate of brass, were gradually heated. At a temperature between 300 and 400°, the whole exploded with a very sharp and loud report, and the plate was pierced and torn. The round aperture was about an inch in diameter, and the lacerations extended much farther.

It was observed that the same effect might be produced by applying a spark to fulminating gold less heated; and that the accension of all such fulminating compounds, by a spark applied to any part, or by due augmentation of the temperature of the whole, is ea-

fily explicable on the grounds mentioned in the minutes of the laſt meeting; provided due attention be paid to the ſtate of the active ingredients.

In fulminating gold, for inſtance, the attractive powers tending to produce the new combinations which take place in the inſtant of combuſtion, ſeem to be almoſt equal to thoſe by which the aggregation of this compound is maintained at low temperatures. For a ſmall augmentation of temperature, or friction, or percuſſion, or any thing which diſturbs the arrangement of the gaſſeous principles and Caloric which adhere but weakly to the gold, is ſufficient for the exploſion of the whole; provided the fulminating gold be pure and dry.

In reſpect to the perforation of the braſs plate, it was obſerved that all bodies which explode inſtantaneouſly would impreſs it in a ſimilar manner. For the reſiſtance of the air to projectiles, or to expanſions of this kind, being in the ratio of the ſquares of the velocities of the moving or expanding bodies; the reſiſtance of the air to ſuch inſtantaneous exploſions as thoſe lately mentioned, is almoſt equal to that of a ſolid, or of the metallic plate

plate on which the fulminating body is heated.

Small portions of fulminating silver, each weighing less than a grain, were successively exploded, some by the touch of a slender brass wire, others by that of a feather.

A description was given of many other specimens which had been inadvertently exploded and lost; some by overheating them to about 90°, in the place where they were to be dried; and others by an accidental concussion of a great iron plate on which they were placed in separate cups.

The experimenter said that he had often exploded fulminating silver in covered vessels of the smallest capacity that could be used with safety; and that this substance had frequently exploded unexpectedly in his hand, with a report louder than that of a musket.

A luminous and momentary gleam was always visible; but he could not discover any other adequate effect of the emitted Caloric; and therefore he concluded, that in such instantaneous explosions, the Caloric was ex-

pelled with velocity ſufficient to conſtitute Light.

Mr. BERTHOLET the inventor of Fulminating Silver, having contented himſelf with a general and conciſe deſcription of this ſubject, many practical Chemiſts have failed in their attempts to prepare it; and others forming their opinions from the ſpecimens which they had made, have been expoſed to great danger; as will appear from the following relation, which is the only part of the minutes on this ſubject that can be introduced in the preſent publication.

An ounce of fine Silver was diſſolved in the courſe of eight hours, in an ounce of pure Nitrous acid of the London Pharmacopœia, diluted previouſly with three ounces of diſtilled water in a glaſs matraſs. The ſolution being poured off, the reſiduary black powder and the matraſs were waſhed with ſeven or eight ounces of warm diſtilled water, and this was added to the ſolution. The black powder being gold, was rejected: ſome gold being thus ſeparable from any Silver of Commerce.

To the foregoing diluted ſolution, pure Lime water prepared with diſtilled water was

added

added gradually: for the ſolution ought not to be poured into the Lime water. When about thirty pints of Lime water had been expended, and the precipitate had ſubſided, more Lime water was added by ſucceſſive pints, as long as it cauſed any conſiderable precipitation. For it was deemed fitter that the precipitation ſhould not be perfected, than that an exceſs of Lime water ſhould be uſed: the earthy pellicle of the exceſſive Lime water being apt to mix with the precipitate. The clear liquor being poured away, the precipitate was poured off and waſhed into a filter.

When the ſaline liquor had drained from it, two ounces of diſtilled water were poured on the magma; and when this water had paſſed, freſh portions were ſucceſſively added and paſſed, until the whole quantity of water thus expended in waſhing away the Nitrous calcareous ſalt, amounted to a quart.

The filter being then unfolded, to let the magma of oxyd of Silver ſpread on the flattened paper; it was placed on a chalkſtone to accelerate the exſiccation, and was gradually dried in the open air; a cap of paper being placed looſely over it to exclude the duſt.

When the weather ſerved, the cap was removed to expoſe the oxyd to the rays of the ſun, although this was not deemed neceſſary; and the exſiccation was promoted by cutting the oxyd into thin ſlices. When perfectly dry it weighed 1 oz. 4 dt. and about one-fifth of it was conſidered as oxygen.

" When aqua ammoniæ puræ of any " Pharmacopœia is uſed with this oxyd, " either in the ſmall quantity which blackens " it compleatly, or in a greater quantity; " the black matter which ſubſides, and " which has been repreſented by ſyſtematic " writers as the fulminating compound, has " no ſuch property, any farther than may " be owing to the matter depoſited from the " alkaline ſolution during the exſiccation.

" The alkaline liquor containing the ful- " minating ſilver, ought to be poured off from " the inſoluble powder, and expoſed in a " ſhallow veſſel to the air. In conſequence " of the exhalation, black ſhining cryſtals " form on the ſurface only, and ſoon join to " form a pellicle. As this pellicle adheres a " little to the ſides of the veſſel, or maintains " its figure, the liquor may be poured off by " a gentle inclination of the veſſel.

" This

" This liquor will yield another pellicle in
" the ſame way; but the third or fourth pel-
" licle will be paler than the former and
" weaker in the exploſion. The firſt pellicles
" when ſlowly dried, explode by the touch
" of a feather, or by their being heated to
" about 96°.

" The quantity of water in the ordinary
" aqua ammoniæ puræ, renders it leſs active
" in the ſolution of the oxyd, and is an im-
" pediment to the ſpeedy formation and ſepa-
" ration of the fulminating Silver; and an
" experimenter who has often uſed twenty
" grains of the oxyd, to produce ſucceſſive
" pellicles of fulminating ſilver, which may
" be ſeparately exploded with ſafety; and
" who has perceived that the pellicles never
" explode whilſt wet, if they be not heated;
" would in all probability reſolve on the fol-
" lowing improvement, and expoſe himſelf
" to the unforeſeen danger of it."

Diſtilled water was impregnated with as much pure ammoniac as it could eaſily retain under the ordinary temperature of the air. A quantity of this ſtrong ammoniacal liquor,

equal in bulk to a quarter of an ounce of water, was placed in a ſmall bottle, and 24 grains of the oxyd of ſilver ground to fine powder were added. The bottle being almoſt filled, was corked, to prevent the formation of that film which uſually appeared in conſequence of the exhalation of the ammoniac, in other experiments.

During the ſolution of the oxyd, bubbles of the gaſſeous kind aroſe from it, and the ſolution acquired a blue colour.

As no film appeared, the bottle was agitated three or four times in the courſe of as many hours, in order to promote the ſolution of a ſmall quantity of blackened oxyd which remained at the bottom.

The experimenter conſidering this as an ample proviſion for twenty different charges, to be exploded in different circumſtances, in the preſence of the Society; intended to pour off the ſolution into as many ſmall veſſels, and to weigh the reſiduary black powder, after allowing two hours more for the ſolution.

On the ſixth hour, he took his uſual precaution of wearing ſpectacles, and obſerving that a ſmall quantity of black powder ſtill re-

mained undiſſolved, and that no film was yet formed at the ſurface; he took the bottle by the neck to ſhake it; knowing that it might explode by the heat of his hand, if he were to graſp it, and that the exploſion in this circumſtance might wound him dangerouſly.

In the inſtant of ſhaking, it exploded with a report that ſtunned him. The bottle was blown into fragments ſo ſmall as to appear like glaſs coarſely powdered. The hand which held it was impreſſed as by the blow of a great hammer, and loſt the ſenſe of feeling for ſome ſeconds, and about fifty two ſmall grains of glaſs were lodged, many of them deeply, in the ſkin of the palm and fingers. The liquor ſtained his whole dreſs, and every part of the ſkin that it touched.

Thus it appeared that fulminating ſilver may be made, which will explode, even when cold and wet, by the mere diſturbance of the arrangement of its parts, in the aqueous fluid.

In ſubſequent experiments privately and carefully conducted, it ſeemed that the property of exploding in the cold liquor by mere commotion, depended on the unuſual quantity or proximity of the exploſive mole-

cules

cules in a given bulk of the liquor. And the flat bottoms, as well as the ſides of the thick veſſels of glaſs or Potter's ware, whether they ſtood on boards or on Iron plates, were always beaten to ſmall fragments.

This afforded a curious inſtance of the poſſible equilibrium between the powers tending to retain the Caloric and thoſe which effect the expulſion of it. And experiments and conſiderations of this kind ſeemed to promiſe a true ſolution of the phenomena of RUPERT's drops.

Small charges, each conſiſting of a grain of oxygenated muriat of Pot-aſh finely powdered and mixed with an equal quantity of flowers of ſulphur, were exploded by mere trituration. And Mr. GODFREY's relation of the danger of keeping ſuch a mixture in a bottle was duly noticed; for after he had kept it thus for ſome time, he found that it had exploded ſpontaneouſly.

Improved proceſſes for oxygenated muriatic acid, and oxygenated muriat of Pot-aſh were ſhewn on this occaſion, the particulars of which muſt be transferred to the publication of the next year, together with the new obſervations made on theſe curious ſubjects.

During the diſcuſſion of the character and uſes of this acid, a piece of grey cotton was bleached in the courſe of a few minutes, and a piece of grey linen in about half an hour, in the manner of BERTHOLET.

On this occaſion Mr. ROBINSON ſaid, "although this method anſwers for Cotton, "the fibres of which are ſlender and eaſily "blanched; the bleachers of Linen do not "adopt it. For they have found by experience that in the time neceſſary for bleaching the coarſer fibres of Linen, the acid "injures the texture of the finer; and Linen bleached with this acid, becomes yellow in the alkaline or ſaponaceous liquors "generally employed in waſhing." This he attributed to a partial combuſtion by the action of the oxygen, in conformity with the notions of BERTHOLET.

The experimenter expreſſed a doubt whether this effect ought not to be imputed to another

other cauſe which may be the ſubject of future inveſtigation.

About this time experiments on the fermentation of melaſſes, and the rectification of the ſpirit, were carried on. But it was not deemed neceſſary that any thing relative to this ſubject ſhould appear in the minutes of the firſt ſeſſion.

Whilſt the Printer was working this page, the Experimenter was honoured with a letter from Doctor Powel. As it relates to the correction of an error, and admits of no abbreviation, the Editor begs leave to inſert it in this place.

"Dear Sir,

"My reſidence at Brighton during the ſummer months prevented me from availing myſelf of the general offer made during that time

time to the Members of the Society, respecting the correction of those parts of the minutes in which any of them were particularly concerned; I am therefore highly obliged by the indulgence you offer me at this advanced period of the publication, and wish you to insert any part of the following statement which you shall think suited to apologize for the question I proposed, and to explain the idea under which I ventured to interfere.

"In some books on the subject of suspended animation, I saw that the destruction of animal life, whether by immersion in carbonic acid gas or in water, was attributed to one and the same affection of the system, and I knew the opinion of some excellent Philosophers to be entirely different—My own observation of some chance Experiments had only gone so far as to ascertain a very material difference in the time in which its dissolution was brought about by these means; in consequence of which I fancied that an atmosphere of carbonic acid gas did more in the one instance than simply shut out oxygenous gas from the immersed animal. I drew also a similar inference from Mr. LAVOISIER's account of the respiration of oxygenous gas by

Guinea pigs; where it appeared that if an animal be removed from a jar of oxygenous gas which he has in a confiderable degree vitiated and rendered unfit for the farther fupport of life, till the carbonic acid gas formed during his expofure is abforbed by cauftic Alkali, he will on a fecond immerfion be able to exift in the remainder, which he could not have done previous to this abforption, notwithftanding the prefence of a fufficient proportion of oxygenous gas to fupply his neceffary expenditure.—I confidered that if an atmofphere of carbonic acid gas deftroyed life, only by the exclufion of oxygen, that an animal, expofed in a mixture, equal or greater in its quantity of oxygen than atmofpheric air, the remainder of which fhould be carbonic acid gas inftead of azotic, ought to fubfift therein as long at leaft as in an equal quantity of air from the atmofphere, and I made the following experiment, that the fact might be in fome degree afcertained.

"Exp. I.—A full grown bird was immerfed in a mixture of $\frac{3}{8}$ of oxygenous and $\frac{5}{8}$ of carbonic acid gas, in a veffel fimilar to that defcribed in the minutes, and he furvived the immerfion but a few feconds.

"I en-

"I endeavoured to obviate any objection that might arise from the greater specific gravity and consequent subsidence of the carbonic acid gas, by fixing a syphon to the end of a common injecting syringe, filling it with water and forcing it briskly up the vessel previous to the introduction of the bird, and thus to produce their intimate mixture. The animal was immediately introduced, and as immediately affected, so that no alteration could have taken place from this cause; and even if there had, such an objection would tell in favor of the conclusion drawn from the Experiment; for the partition was so high up in the vessel, that if the carbonic acid gas had subsided into an inferior stratum, the bird would have breathed nothing but pure oxygenous gas. I thought likewise to prevent the carbonic acid gaseous part of the mixture from being subtracted by the water, by previously impregnating it with a considerable quantity in NOOTH's apparatus.

"EXP. II.—A mixture of $\frac{3}{8}$ of oxygenous and $\frac{5}{8}$ of carbonated hydrogenous gas was made in the same vessel, and a bird introduced which died instantaneously and could not be recovered.

"The carbonated hydrogenous gas was procured

cured from powdered charcoal and was washed over lime water, to remove any carbonic acid gas that might be present.

"This experiment was made with a view to ascertain whether Carbone most minutely divided by solution in hydrogenous gas would affect animal life, for this was the only ingredient in the mixture that could produce any effect in so short a time; since I know from another experiment, that an animal will live well in a mixture which contains the same proportions of simple hydrogenous and oxygenous gasses."

"The proportion of oxygenous gas in each experiment, was larger than was necessary to form a mixture of the standard of atmospheric air, in order to allow for impurities, as the gas was obtained from Nitre."

"Exp. III.—The same vessel was filled at the same time with the same quantity of common air from the Laboratory, and the bird used in Experiment I. which had been withdrawn in time for its recovery, was introduced, and suffered no great apparent inconvenience during five minutes, when he was liberated."

"Here and in the experiment with simple hy-

hydrogenous gas, the veſſel was agitated over lime water to promote the abſorption of the carbonic acid gas ſecreted by the animal.

"The experiment which you have done me the honor to record as mine in the text, was made by Mr. Abernethy, and was mentioned by me becauſe it ſeemed ſufficient to decide how ſpaſmodic affection of the Larynx was concerned.

"From theſe data I preſumed to propoſe the queſtion which ſtands upon the minutes, and I hoped from the obſervations of the Society to obtain ſome information on the influence of gaſſes in general upon the human ſyſtem; a ſubject upon which I conſidered myſelf as bound to enter ſomewhat particularly in the Chemical Lectures at this Hoſpital; the ſingle performance of theſe experiments was ſufficient for my own ſatisfaction, and I have not choſen by a repetition to make the ſacrifice of life to a leſs laudable motive than the acquiſition of knowledge.

"I am, Sir, with great reſpect,

"Your obliged humble Servant,

"R. POWELL.

"*St. Bartholomew's Hoſpital,*

"*Dec.* 29, 1794."

MINUTES

OF THE

TWENTIETH

BEING AN

EXTRAORDINARY MEETING,

AT NOON,

On Tuesday, June 17, 1794.

Solar Phosphori.

Attempt to convert Oil of Turpentine into Gasses Water and Carbo.

Process for obtaining Regulus of Manganese.

A ROOM was painted black, and provided with double doors and shutters to exclude the Light compleatly. To keep up a free circulation of air, winding tubes of large diameter were placed near the floor and also near

near the ceiling, through which the air might circulate from the adjoining room.

On the eaſtern ſide, a round aperture nine inches in diameter, through which bodies might be preſented to the Light of the ſky, was provided with a valve or hanging ſhutter lined with black cloth, by means of which the aperture might be inſtantly cloſed, to preſent the bodies in a darkened place, when they were withdrawn from the Light.

This conſtruction was adopted from Mr. DELAVAL, in whoſe houſe Mr. WILSON's experiments on Solar Phoſphori were chiefly made.

The ſun being clouded at this unfavourable hour, the gentlemen could ſcarcely ſee the phoſphorence of paper, linen, and ſome others of the weaker phoſphori. But many of the Solar Phoſphori of BECARIA and WILSON, when quickly returned from the Light into the darkened room, and viewed with eyes previouſly prepared for weak impreſſions, by the darkneſs, were diſtinctly ſeen, and ſufficiently luminous to make the neighbouring objects viſible for many ſeconds.

Some ſpecimens made of Bolognian Sul-

phat of Barytes and of Cumberland Sulphat of Barytes, and thoſe made of the materials of BALDWIN's and CANTON's Solar Phoſphori, by improved proceſſes, were ſo luminous as to enable the gentlemen to read the dials of their watches or large print placed cloſe to the lucid body, and to diſtinguiſh each other at a diſtance. Many of theſe ſpecimens were viſibly luminous for ten or fifteen minutes, after being expoſed to the external light during a ſecond, or two at the moſt.

Bodies of other kinds, which become phoſphoreſcent by ſlight incaleſcence, ſuch as green fluor; or by friction, ſuch as HOMBERG's Phoſphorus, and certain Ores of Zinc; were next exhibited in the darkened place.

This opportunity was taken of preſenting the weak and luminous combuſtion of phoſphorus of Kunkel in air, without producing any ſenſible heat; and the gradual increaſe of Light and luminous vapour attended with incaleſcence, whilſt the temperature of the phoſphorus was gradually augmented from 60°, to that at which it flamed and burned rapidly.

The phoſphoreſcence of agitated ſeas, of fiſh,

fiſh, of rottenwood, of glow-worms, and other animals, was ranked under this latter head, and repreſented accordingly.

Reference was made to the books of the Laboratory for the methods of preparing the Solar phoſphori, to the greateſt perfection; and during the exhibition of theſe phenomena, a ſolution conſiſtent with the foregoing notions of Caloric and Light was offered. But theſe particulars muſt be transferred to the minutes of the next year.

An attempt was made to convert oil of Turpentine into gaſſes, Vapour and Carbo, by Caloric only. The apparatus was contrived to paſs the vapour of the oil through ſix ſucceſſive three inch columns of white quartoſe ſand intenſely heated, and to ſave the products. But an accidental failure of the apparatus, ſoon after the experiment was commenced, rendered it improper to offer any report on this ſubject.

During the reduction of the Native Oxyd, called Manganese, to the metallic state, and the formation of the Regulus of Manganese, the rules for the Construction of Furnaces, and for exciting the greatest heat from Coak, were explained and practically exemplified.

The extraordinary measures required for this reduction, being shewn; the singular property of this Regule to become oxydated in the air, without the aid of heat, and from the hardness of Cast Iron, to fall into fine powder in a few hours, was exemplified.

MINUTES

OF THE

TWENTY-FIRST MEETING,

ON

SATURDAY, June 21, 1794.

Experiments ſhewing the Ratio in which the Elaſticity and Denſity of the Gaſſes are augmented with the Compreſſing Forces. And Inferences concerning the relative Diſtances of the Central Particles.

Experiments ſhewing the Methods of Meaſuring the Specific Gravities of Solids, Fluids and Gaſſes.

Attempt to Decompoſe Water by Caloric only.

Formation of Nitrous Acid from Oxygen Gas and Azotic Gas.

Obſervations of Dr. LATHAM.

A MEASURED quantity of air was introduced into an inſtrument ſimilar to that of LAVOISIER, page 408, in which it might be compreſſed with a weight equal to that

of four atmoſpheres, by an high column of mercury. By experiments with this inſtrument it appeared agreeably to the ſtatement of Sir ISAAC NEWTON, that the ſpaces occupied by the air were inverſely as the compreſſing forces, and the denſities of the compreſſed air directly as the compreſſing forces.

His demonſtration of the ratio of the repulſion of the particles at different diſtances of their centers being adopted; inferences were drawn from this experiment and others formerly made on ſimple fluids, in reſpect to the charges of Caloric by which the particles of Elaſtic fluids are made to repel each other. The particulars of theſe ſubjects are unavoidably deferred.

The methods of meaſuring the ſpecific gravities of gaſſes, of ſolids and fluids, by the inſtruments deſcribed by LAVOISIER, in reſpect to the gaſſes, and in NICHOLSON's Philoſophy, in regard to the other ſubjects, were exhibited and practiſed in a variety of inſtances.

An

An experiment was made to determine whether any change could be produced in water, by paſſing the vapour through ſucceſſive columns of pure white quartoſe ſand previouſly heated beyond the degree neceſſary for the fuſion of ſteel.

An earthen veſſel of ſingular ſtructure was uſed for this purpoſe, but it opened at the Potter's juncture, in conſequence of the intenſe heat, and the experiment failed.

A very large and powerful PAPIN's digeſtor, provided with a valve and lever, and charged with two quarts of water, was ſtrongly heated, and employed to ſhew the force of ſteam, the degrees to which water and its vapour may be heated in cloſe veſſels, and the facts quoted by Dr. CRAWFORD from Dr. BLACK, on this ſubject.

Mr. CAVENDISH's important experiment for the decompoſition of oxygen gas and

azotic

azotic gas, and the formation of their bafes into Nitrous acid, concluded the experimental bufinefs of the feffion; but being carried on for an hour only, is not to be further noticed in thefe minutes.

Whilft the Electrical fparks were acting in the apparatus for the compofition of water, and in the azotic and oxygenous gaffes of the laft mentioned Experiment; "Dr. Latham "informed the Society that he had made a "difcovery which might become important, "with refpect to the phenomenon which is "generally called the Electric fpark. He "obferved that the appearance which is "ufually denominated the Electrical fpark, "is not Electrical, but is actual Fire produced "from the decompofition of any aeriform "Elaftic fluid. That it is extricated and "appears in the form of Flame, in confe- "quence of an elective attraction taking "place between the Electric matter and the "bafis of the elaftic fluid, to the exclufion of "the Fire which was combined with it. He "ftated, in proof of his doctrine, that the "fpark is only feen in the line of direction "as it paffes from point to point through an "Elaftic fluid; and that as the air is with-

"drawn,

" drawn, in the receiver of an air pump, the " ſpark appears leſs vivid, ſo that in a va-" cuum there is no evidence of Fire at all; " and yet that a veſſel may be charged with " the Electric fluid which ſo paſſes from point " to point, although it does not manifeſt its " paſſage by the common appearance of ſparks.

" He alſo ſtated that he was particularly " induced to think upon the ſubject from " obſerving the experiment for the formation " of water repeated before this ſociety; where " the hydrogenous gas takes fire upon the " diſcharge of Electric matter, when from " many circumſtances he had previouſly " convinced himſelf that Electric matter had " little or no analogy with it.

" He expreſſed himſelf ſanguine in the " hope that many improvements in philoſo-" phical purſuits might be derived from his " diſcovery, and particularly inſtanced the " theory of Lightning and Atmoſpheric me-" teors, of ſubterraneous fires and tepid " ſprings and earthquakes; and mentioned " ſome other important matters which might " hereafter probably receive elucidation from " a knowledge of the fact which he com-" municated.

" He

" He alſo contended that if the ſpark real-
" ly iſſued as he ſuppoſed from the decom-
" poſed elaſtic fluid, that there might be poſ-
" ſibly found a method of tranſmitting the
" Electric matter in ſuch a manner through
" ſimple gaſſes, as at laſt to exhibit oxygen,
" hydrogen, and azot in a ſolid form.

RESOLUTIONS

TERMINATING

The SESSION.

VARIOUS Members having addreſſed the Chairman to the following effect, the ſociety reſolved unanimouſly;

1. That the thanks of this ſociety be preſented to Marſhal CONWAY.

2. That the thanks of this ſociety be preſented to Sir FREDERICK EDEN, Sir JOHN INGELBY, and Dr. LATHAM, Deputy Chairmen.

3. That the thanks of this ſociety be preſented to Mr. GRUBB, and Mr. TAYLOR, Secretaries.

4. That the thanks of this ſociety be preſented to Dr. HIGGINS, Experimenter.

5. That the thanks of this ſociety be preſented to Mr. JOHNSON, Mr. YOUNG, and Mr. CREVEL, Aſſiſtant Experimenters.

6. That the thanks of this ſociety be preſented

ſented to the members who have taken an active part in the experiments and converſations.

7. That a letter of thanks be written by the Secretary, in the name of the ſociety, to each of the members who have patronized this inſtitution and ſupported it by their ſubſcriptions, under circumſtances which prevented them from attending at the meetings.

8. That an abſtract of the minutes of this ſociety be made and publiſhed by the Experimenter, in ſuch manner as a Committee of Publication ſhall think proper; and that the Committee have full power to regulate all matters reſpecting the expence of the publication.

9. That the Committee conſiſt of the following members.

Sir F. Eden, Bart.	Mr. Partington
Sir John Ingelby, Bart.	Dr. Powel
	Governor Deſbarres
Mr. Coxwell	Mr. Allen
Mr. Lewis	Mr. Hill
Mr. J. Johnſon	Mr. Robinſon
Mr. Symmons	Mr. Young
Mr. Godfrey	

And the other Members whom they ſhall nominate.

10. That every member be conſidered as a ſubſcriber to the ſeſſion of the next year, unleſs notice to the contrary be given to the Secretary or the Experimenter.

11. That the ſeſſion of this year be now cloſed.

In the Committee of Publication, held on the 3d of July, 1794,

It was Resolved unanimously,

1. THAT the title of the intended Publication be, *Minutes of the Society for Philosophical Experiments and Conversations, instituted in London, January* 25, 1794.

2. That the experimenter be requested to announce in a preface to this work, the particulars of this institution, the list of members, and the Resolutions of the 25th of January, 1794.

3. That the minutes be published as nearly as may be convenient, in the present historical order, and be confined to the subjects which were mentioned in the Society.

4. That the quotations made at the meetings of the Society, of improved processes or facts described in the Numerical book of the Laboratory, be inserted as part of the minutes.

5. That

5. That ſuch drawings as may be neceſſary to illuſtrate the ſubjects of the work, be made and engraved.

6. That experiments proving the ſame propoſition, although neceſſarily made at different meetings, may be drawn together in the minutes of either of theſe meetings, to abridge the deſcriptions and the reaſoning.

7. That the Nomenclature of LAVOISIER be adopted, as far as it may be neceſſary; and until the Society ſhall have eſtabliſhed ſufficient facts to warrant a reviſion.

8. That the Committee of publication meet on Thurſdays at ſix o'clock in the evening.

The experimenter being indiſpoſed in July and Auguſt, and the members being out of town for ſome time afterwards, there was no meeting until the 23d of October; when, the manuſcript minutes of the five firſt meetings being read, the experimenter was deſired to proceed.

The next meeting of the Committee was

held on the 18th of December, 1794. The printed ſheets to letter L, incluſive were read by the experimenter.

The Committee ordered that theſe ſheets be ſent to Dr. POWEL and Sir FREDERICK EDEN, with a requeſt that they make ſuch corrections as may be inſerted in a page of errata.

The Committee then reſolved "That the "meetings of the Society for the enſuing "year ſhall commence on Saturday January "31ſt, 1795, and that due notice be given "to the members."

The Committee adjourned to the Laboratory, and examined the water which was compoſed in the manner deſcribed in the minutes. They found it to be perfectly free from acid, but to have a ſlight flavour, which to ſome reſembled that of ſpermaceti, but to others that of water into which a drop of melted tallow had fallen.

The experimenter obſerved that this flavour came from the Tallow with which the ſhoulders of the cocks and the collar of Leathers, and the glaſs ſtoppers muſt neceſſarily be greaſed.

Sir FREDERICK EDEN's engagements prevented

vented him from looking over the Copy; and Dr. POWEL, who obligingly ſent a liſt of Typographical errata, as far as page 162, of this work, was called out of town, and prevented from ſeeing the remainder until it was publiſhed.

It is ſcarcely neceſſary to add, that the Editor could not perceive the Typographical errors or even the errors in diction; becauſe his corrections of the preſs were neceſſarily made immediately after the copy was written, and whilſt it was ſo freſh in his memory, that he almoſt had it by heart.

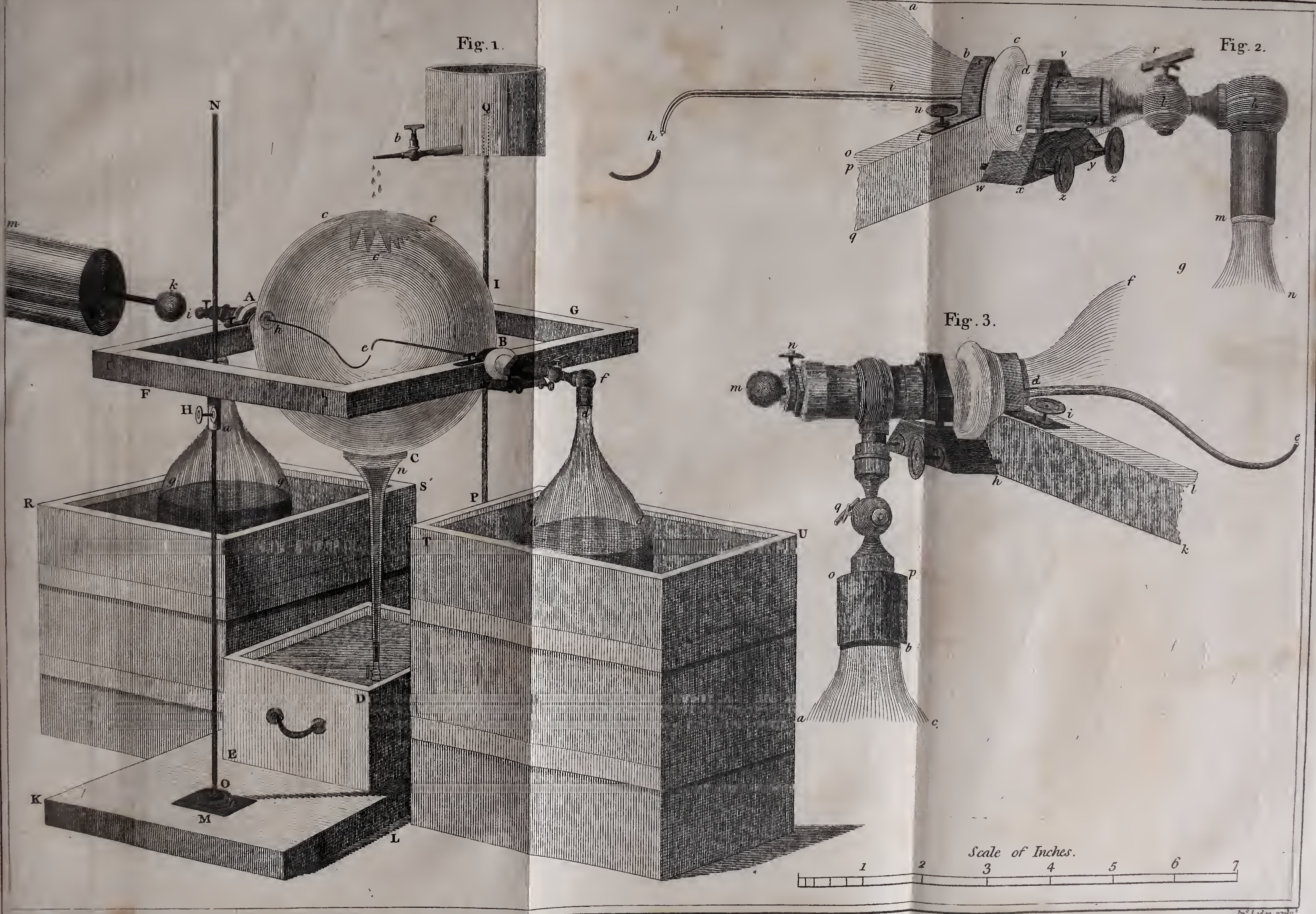
The imperfections and errors of a publication made under theſe circumſtances, are imputable to the Editor only, and will be forgiven. But for the future, the compleat Copy muſt be laid before the Committee of Publication, to be reviſed and corrected at their leiſure.

FINIS.

ERRATA.

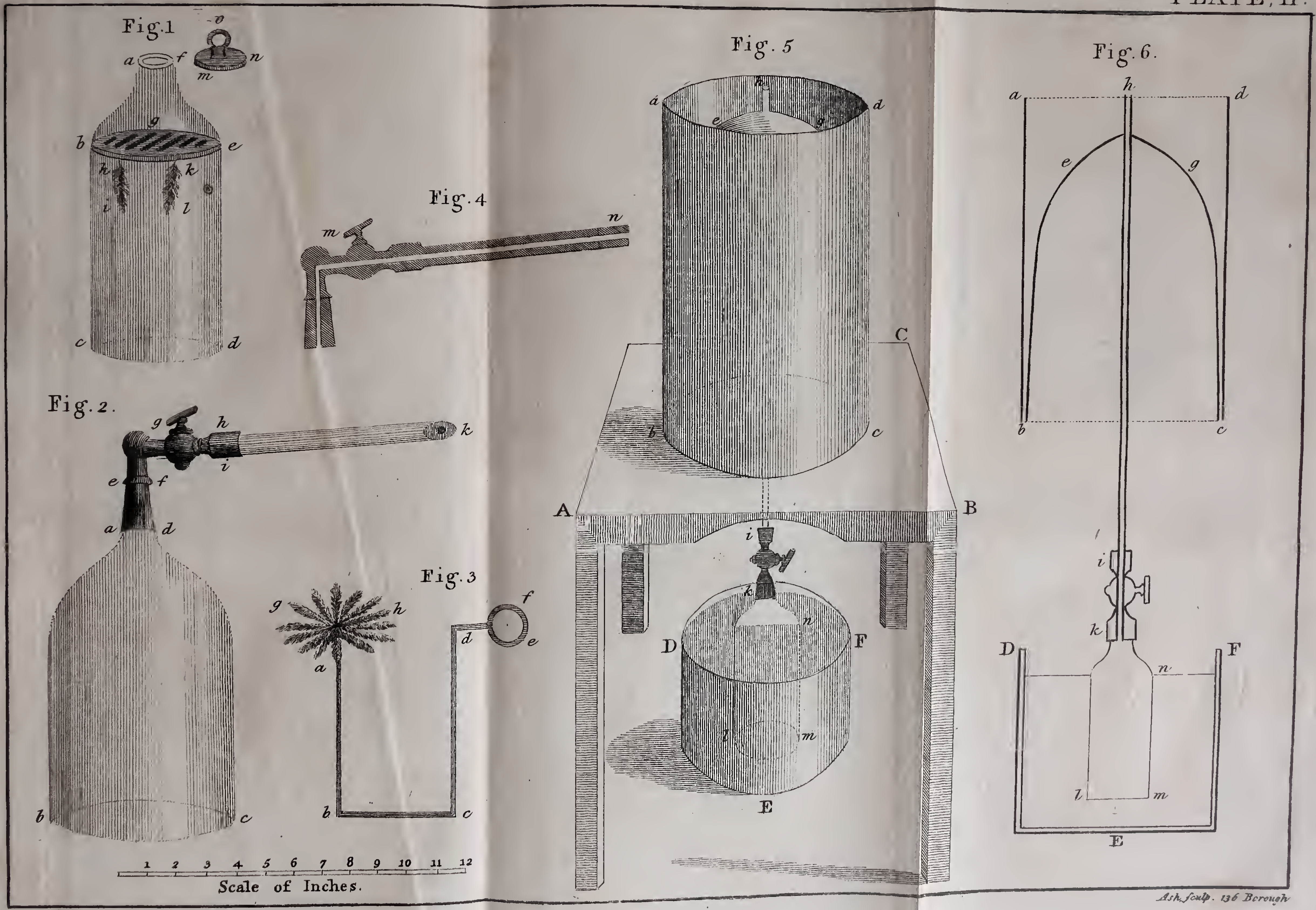
Page 6,	l. 19,	*for*	1794,	*read*	1793.
15,	3,		oxigen,		oxygen.
50,	20,		oxigen,		oxygen.
50,	12,		oxyde,		oxyd.
	26,		oxyde,		oxyd.
111,	2,		oxyde,		oxyd.
53,	12,		oxyen,		oxygen.
61,	8,		ad,		and.
	16,		drawan,		drawn.
81,	4,		Ferenheit,		Fahrenheit.
82,	15,		a,		in a.
83,	13,		muriac,		muriatic.
107,	15,		oxgen,		oxygen.
122,	12,		harhsicord,		harpsichord.
153,	1,		est,		lest.
158,	1,		reurned,		returned.
162,	18,		ozygenation,		oxygenation.
217,	7,		$\frac{1}{25000}$		$\frac{1}{250000}$

PLATE I.



Ferd. Eden, Baron ? delin.

Jn. Lodge sculp.



Fred. Eden. Baronettus Delin.

PLATE. III.

PLATE. IV.

318
159
330
300